DOMESTIC NUCLEAR SHELTERS

TECHNICAL GUIDANCE

A HOME OFFICE GUIDE

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WITHDRAWN

Contents

Introduction

This manual of technical guidance on the design of domestic nuclear shelters has been prepared by a working group set up by the Emergency Services Division of the Home Office. The working group was asked to consider designs of nuclear shelters which could be made available to members of the public in the United Kingdom who might wish to purchase and install shelters for the use of themselves and their families.

The working group realised that the range of designs which it might produce would not be exhaustive. However, it was aware of the need to give technical guidance to professional engineers to assist them in producing reliable shelter designs. Thus the first three chapters of this book are written to give such guidance.

The other four chapters of the book give detailed designs of five shelters. These five cover a range of types which are applicable to different sorts of houses; they also cover a wide price range. These designs are not intended to be exhaustive, and as explained in the text, the working group is already giving attention to other designs, particularly those which might be incorporated into existing or new houses and also underground shelters of shapes other than box-like and using materials other than concrete. It is planned to publish details of this work at a later date.

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Light and heat energy 1.1.3

This energy consists of visible light, ultraviolet and infra-red rays. The ultraviolet rays are quickly absorbed by the air but the light and infra-red (heat) rays travel great distances and are emitted for several seconds—up to about 20 seconds for a 20 megaton explosion. The intensity of the direct heat radiation received at particular places will depend on such factors as dust, fog, or atmospheric pollution, all of which could absorb much of the radiation. Under *clear* conditions the ranges in Fig. 1 might apply. Distances are in kilometres (miles).

Fig. 1 ***Ranges of heat effects***

	Ground burst		Air burst	
	Main fire zone	**Second degree burns**	**Main fire zone**	**Second degree burns**
1MT	$2\frac{1}{2}$–8 ($1\frac{1}{2}$–5)	10 (6)	3–13 ($1\frac{3}{4}$–8)	15 (9)
10MT	6–19 ($3\frac{1}{2}$–12)	26 (16)	7–32 (4–20)	39 (24)

In the main fire zone, houses not totally destroyed by blast could catch fire. Second degree burns would be sustained by exposed skin. These would be the maximum ranges at which the effects would occur. On most days in the UK the ranges would be much less because of climatic conditions.

To obtain some protection from the heat it is necessary to move out of the direct path of the rays from the fireball; any kind of shade will be of some value. In shelter design, any materials affording protection against ionising radiation or blast will give more than adequate protection against the heat. However it is important to ensure that no exposed parts of the shelter (such as the facings of doors) are made of flammable materials. In the case of shelters made from plastic materials such as GRP (glass reinforced plastic) it is essential that no surfaces should be exposed to the heat pulse. It is unlikely that such plastic materials would catch fire, but they may melt or distort. Since the blast wave follows the heat pulse, such distorted areas may result in lowered blast resistance.

It is considered unlikely that the heat flash from a nuclear explosion would give rise to fire-storms. In the last war, fire-storms were caused in the old city of Hamburg as a result of heavy incendiary attacks and at Hiroshima but not at Nagasaki. A close study of these cities and of German cities where fire-storms did and did not occur revealed several interesting features. A fire-storm occurred only in an area of several square miles, heavily built up with buildings containing plenty of combustible material and where at least every other building in the area had been set alight. It is not considered that the initial density of fires, equivalent to one in every other building, would be caused by a nuclear explosion over a British city. Studies have shown that due to shielding, a much smaller proportion of buildings than this would be exposed to the heat flash. Moreover, the buildings in the centres of most British cities are now more fire-resistant and more widely spaced than they were 30 to 40 years ago. This low risk of fire-storms would be reduced still further by the control of small initial and secondary fires.

There are two main hazards from a large area of fire to the occupants of shelters. One is the transmission of heat through the earth and shelter wall. In most cases this would make for discomfort rather than danger, particularly in underground shelters. The major danger is the possibility that the gaseous products of combustion, mainly carbon dioxide and perhaps carbon monoxide, might be drawn into the shelter. These dangers may be mitigated by taking advantage of the fact that the arrival of fallout is unlikely to occur for about half an hour after the explosion and a fallout warning will be given (for details see the booklet *Protect and Survive*). The intervening time might be used to try to extinguish or damp down any nearby fires. This may not be possible in many cases where a fallout warning has already been given based on ground bursts further upwind than the local bomb.

Crater formation and ground shock 1.1.4

When a nuclear weapon bursts near the ground much of the energy is expended in making a crater. At the same time a shock wave is transmitted outwards through the ground.

Crater formation

A large amount of vapourised or pulverised material is sucked up by the ascending fireball. Larger amounts are gouged out and deposited on the perimeter of the crater making an elevated lip roughly equal in width to the radius of the crater itself. The size of the crater, for a weapon of given power, will depend on the nature of the ground and

crater dimensions for weapons of various powers in different soils are given in Table 8 of *Nuclear Weapons*. Those figures are not repeated here since in themselves they have no relevance to shelter construction. What is of importance for shelter construction is the ground shock which is propagated outwards from the crater.

Ground shock

The ground shock effects of a megaton surface burst are similar to those of an earthquake of moderate intensity, but the pressure in the ground shock wave decreases more rapidly with distance. The ground shock effects on buildings above ground are irrelevant since they do not occur beyond the distances at which those structures are in any case destroyed by air blast. The effect of the ground shock on structures below ground depends on the ability of those structures to adjust to the ground movement. Damage will depend on:

Duration of blast wave (hence power of weapon).	Moisture content of soil.
Type of soil.	Depth of the structure below ground.
	The shape of the structure.

Small, self-contained structures will generally move bodily with the earth movement; a spherical or similarly shaped structure is better than one irregularly shaped; flexible structures usually adjust to some ground movement, particularly long flexible structures such as pipes. A rigid rectangular structure, such as a concrete box, would be vulnerable to earth movement at its edges and particular attention must be paid to the reinforcing links at these locations. The information in Fig. 2 is taken from *Effects of Nuclear Weapons* and refers to structures in wet clay. Distances would be halved in dry rock. 'Moderately deep' is defined as structures where the ratio of depth of cover at the crown to the span is greater than unity. More deeply buried structures would suffer less damage.

Fig. 2 ***Damage criteria for moderately deep underground structures***

Type	Damage type	Metres (feet) from 1 MT GB	Nature of damage
Relatively small, heavy well-designed structures	Severe	450 (1,500)	Collapse
	Light	850 (2,800)	Slight cracking; severance of brittle external connections
Relatively long flexible structures; e.g. buried pipes and tanks	Severe	500 (1,700)	Deformation and rupture
	Moderate	670 (2,200)	Slight deformation and rupture
	Light	850 to 1,000 (2,800 to 3,300)	Failure of connections

Thin-walled, self contained structures buried in wet clay should be undamaged by ground shock if sited at a distance greater than 1,000 metres (3,300 feet) from the ground zero of a ground burst megaton weapon. In dry ground the structures would be undamaged by ground shock at a smaller distance from ground zero.

This is not the whole story however. At locations where structures would suffer only light damage from ground shock the overpressure in the blast wave from one megaton explosions would be of the order of 2,800 kiloPascals (400 psi), and this would be the major factor causing damage. This subject is dealt with in the next section. None of the shelter designs given later take ground shock into account. Most do however give some protection against air blast.

1.1.5 Air blast

Characteristics of the blast wave

When an explosion occurs, a blast wave is propagated away from the point of burst. The distribution of overpressure (i.e. the excess above atmospheric pressure) along a radial line from the centre of burst is indicated in Fig. 4. The blast wave travels with a characteristic velocity and peak overpressure. This decays behind the front as shown in Fig. 4. At the same time the air behind the front is moving outward at a high velocity and this wind produces 'drag' forces on any object encountered. At a fixed point on the ground the variation of overpressure and dynamic pressure with time is shown in Fig. 5.

Fig. 3 gives some quantitative information on the relationship between the various parameters of the blast wave. In this table, the last column refers to the duration of the positive phase of the blast wave, i.e. the time between blast arrival and the first return to ambient pressure.

Operation of fan

The fan should be set in operation as soon as the shelter is occupied and the outside doors closed. It should be closed down immediately following attack to prevent the filters blocking due to the air following the blast wave being contaminated with dust particles both from the ground and from any falling buildings. *These particles will not be radioactive.* Similarly the ventilation should be shut down when the fallout is expected to arrive. This information would be given by radio. It may be necessary to shut down in the event of nearby external fires to prevent fumes entering the shelter.

There is a limit, however, to the length of time during which it is safe to shut down the ventilation. The determining factor is the build up of carbon dioxide in the atmosphere. A level of 4 per cent carbon dioxide is dangerous; a level of 2.5 per cent can be tolerated by healthy people for a short period (say half an hour to one hour); a more comfortable limit is 1.5 per cent. Formulae giving the time of shut down of ventilation from the volume of air space per person for a limit of 1.5 per cent, 2.5 per cent and 4.0 per cent carbon dioxide are given below. These assume that the people are resting and they are based on a carbon dioxide production rate of 0.017 cubic metres per person per hour (0.6 cubic feet/person/hour).

For 1.5% $t = \frac{V}{N} \times \frac{1.5}{1.7}$

For 2.5% $t = \frac{V}{N} \times \frac{2.5}{1.7}$

For 4.0% $t = \frac{V}{N} \times \frac{4.0}{1.7}$

Where:

t is time in hours

V is the total volume of shelter in cubic metres

N is the number of people in the shelter

During the operation of the ventilation and on restarting the ventilation after a shut-down a check should be made on the air flow rate gauge to ensure adequate air supply. A drop in the air-flow rate whilst the fan is in operation will indicate a blockage, most probably at the air inlet cowl. In this event it will be necessary to leave the shelter to clear the air inlet taking precautions before leaving and re-entering (see section 1.1.7). If the air inlet cannot be cleared then it will be necessary to open the doors to the outside; in this case the occupants should keep as far from the door as possible and away from direct line of sight to the outside.

Humidity and comfort 1.2.3

At the minimum air flow rate to maintain safe levels of carbon dioxide the ventilation will not necessarily control the temperature and humidity. Portable gas- or paraffin-fired lighting and cooking should not be used in the shelter whilst in the closed down condition. They should only be used if the door can remain open safely and then be sited near to the open door or under the open hatch. Smoking in moderation may be safe if it is carried on near to the air extract vent whilst the ventilation is in operation.

Radio reception 1.2.4

For some days the only contact with the outside world will be by radio. Wartime broadcasting will be on the medium wave band or on VHF. Since radio reception in a shelter may be seriously attenuated it is essential to have a radio with an external aerial socket so that, if necessary, an aerial outside the shelter can be connected to the radio. Radio reception should be tested when the shelter is constructed or installed.

Toilet arrangements 1.2.5

Some form of chemical toilet will be necessary. This can conveniently be of the type used in caravans; some of these can be used for a number of days without producing unpleasant smells. At some point the contents of the toilet must be taken outside. This can be done quite safely if it is carried out quickly. Preferably the occupants should take turns with this to reduce the level of radiation doses received by any one individual.

1.2.6 Food and water storage

Advice is given elsewhere on the kinds of food which should be taken into the shelter. But in the shelter design provision must be made for food storage and most importantly, water storage. Water should be stored sufficient for at least 2½ litres (4 pints) per person per day for 14 days. This will allow a small amount for toilet and washing purposes. It can be stored in plastic containers and these can be in the least protected part of the shelter. Water and food do not become radioactive or dangerous by being exposed to radiation. They only become contaminated if the dust settles on the food or in the water.

1.2.7 Emergency exit

In large shelters, the provision of an emergency exit remote from the main entrance is essential. In small family shelters the provision of an emergency exit is of less value, since it can only be sited within a few metres of the main entrance. However, in designing a shelter there are several matters which might be considered to ensure, as far as possible, that exit from the shelter will be possible if debris is deposited outside (see section 1.1.5).

Canopy over the door. In cases where the entrance to the shelter is down a ramp, it should be possible to build a canopy over the entrance to the doorway to prevent debris blocking the door.

Sand filled tunnel. In a concrete shelter, a section of the wall remote from the entrance can be replaced by a metal plate or masonry. A tunnel to the surface beyond this can be filled with sand which could easily be removed to gain access to the outside. Such an alternative arrangement is indicated in the concrete shelter in Chapter 7 of this book.

Tools. Picks and shovels should be part of the shelter equipment. If no special emergency exit is arranged it is essential, in the case of a hatch cover entrance, to provide some means of lifting the shelter door by mechanical means in case it is covered by debris or branches of fallen trees.

1.2.8 Shelter entrance

This should be of the correct type to withstand the design overpressure of the shelter. Information on this is given in Chapter 3 of this book. The main blast door would always be outward opening to ensure that the blast overpressure is more safely distributed across the entrance. Provision should be made for the removal of this blast door from the inside to aid escape.

If there is sufficient space it is worthwhile considering the provision of a ramped entrance to the shelter rather than a hatch cover and ladder. This will make entrance and exit easier for the elderly and incapacitated.

1.2.9 Interior fitments and decor

In purpose-built shelters (which are not inexpensive) it will be worthwhile considering the types of fitments and colours to avoid a universal drabness. This might be achieved by some form of light colours on the walls or even posters, a familiar carpet on the floor, etc. White or light coloured walls will also have the advantage of reducing the intensity of light required in the shelters.

Interior light can be supplied by batteries. These can be dry batteries or a car battery, fully charged before being taken into the shelter. Battery-powered fluorescent lighting is now available and this is more efficient in terms of battery life.

Fig. 14 ***Suggested food stocks for two weeks*** (2000 calories/day/person)

Item	For one person
Biscuits, crackers, breakfast cereals etc.	2750 g
Tinned meat or fish (e.g. tinned beef, luncheon meat, stewed steak, pilchards, sardines)	2000 g
Tinned vegetables (e.g. baked beans, carrots, potatoes, sweetcorn etc.)	1800 g
Tinned margarine or butter, or peanut butter	500 g
Jam, marmalade, honey or spread	500 g
Tinned soups	6 tins
Full cream evaporated milk (or dried milk)	14 small tins (2 x 300 g containers)
Sugar	700 g
Tea or coffee (instant)	250 g
Boiled sweets or other sweets	450 g
Tinned fruit, fruit juices, fruit squash, drinking chocolate	If sufficient storage space is available
Approximate cost (mid-1980)	£15–£20

Children over five and adults

It is best to concentrate on foods of high energy value: a normally healthy person can survive without a properly balanced diet for many weeks. Salty or highly spiced foods should be omitted during the 'lie-low' period as should salt itself. The greatly increased requirement for water which salt brings about would be extremely difficult, if not impossible, to satisfy with a limited water supply. No adverse effects will result from the exclusion of salt from the shelter diet.

Variety in foods

The list in Fig. 14 should not be regarded as a hard and fast shopping list. It is important to remember that favourite or familiar foods will be important psychologically. There is room for flexibility both within and between groups of foods. Fats could be decreased by 250 g and cereals increased by 450 g; or 350 g of tinned meat could be substituted for the boiled sweets. If storage space is limited then the tinned fruit and fruit juices can be omitted but these items do increase the variety of the diet and provide some liquid intake.

Turnover of food stocks

If a regular stock or emergency supply of food is to be kept it is necessary to replace all tinned goods at least once every two years using and replacing the oldest stocks first (those containing acid fruits like tomatoes or pineapple, and evaporated milks, will only be at their best for about six months). Packeted foods should be replaced at least every six months. Cereals should not be kept for very long periods and their storage life is approximately four to six months. Biscuits and similiar items should be kept in a metal container.

Use of perishable foods

When an attack appears imminent perishable foods including those in freezers and refrigerators should be eaten first, and other household stocks reserved for the emergency store. When the electricity supply ceases, food in freezers will gradually thaw and then deteriorate; nevertheless it and other perishable items can make a useful addition to the diet for the first few days in the shelter.

1.5.3 Tools

In Type 3 and Type 4 shelters, particularly those sited below ground it is especially important that tools be stored in the shelter to enable the occupants to dig themselves out should occasion arise. A pick and spade are essential; in the case of a trap door entrance, some form of lifting gear would be desirable in case debris or tree branches have fallen over the entrance.

In the Type 2 shelters a spade would be essential in case of house collapse onto the shelter. This might also apply in the case of the *Protect and Survive* core shelter.

1.5.4 Other supplies

A study should be made of the contents of *Protect and Survive,* particularly pages 14 to 17. The supplies there may need to be adapted to the particular form of shelter being stocked. But all the classes of items are important and so are listed here:

Portable radio (receiving medium wave) and spare batteries. A spare radio would be desirable. In the case of shelter Type 3 and Type 4 it is essential to have a radio with an aerial socket. A make-shift aerial can be fitted up passing to the outside of the shelter. A socket on the radio is then necessary to receive the connection to the aerial.

Tin opener, bottle opener, cutlery and crockery.

Warm clothing, and changes of clothing.

Bedding, sleeping bags, etc.

Saucepans, food containers.

Torches with spare bulbs and batteries.

Toilet articles, toilet rolls, plastic buckets.

Overalls or an outdoor coat which can be left near the shelter entrance in case you have to go outside the shelter.

First aid kit and simple remedies.

Box of dry sand, cloths or tissues for wiping plates and utensils.

Notebooks and pencils.

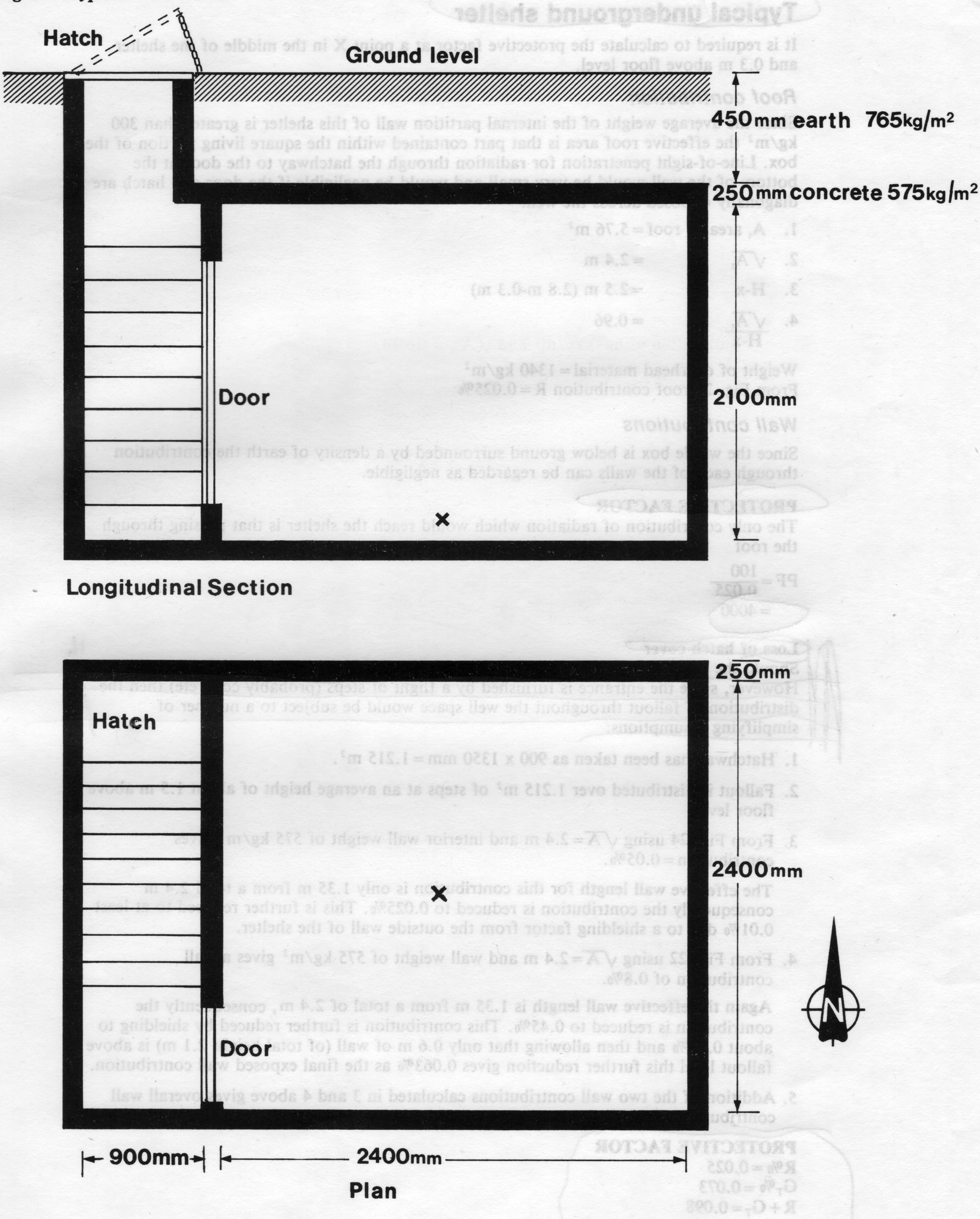
Games, toys, magazines.

Clock (mechanical) and calendar.

Sanitation supplies such as polythene bag linings, strong disinfectant.

Two dustbins or buckets, one for temporary storage of sealed bags of waste matter and one for food remains, empty tins and rubbish.

Fig. 28 *Typical 'box' shelter*



Typical underground shelter

It is required to calculate the protective factor at a point X in the middle of the shelter and 0.3 m above floor level.

Roof contribution

Since the average weight of the internal partition wall of this shelter is greater than 300 kg/m^2 the effective roof area is that part contained within the square living portion of the box. Line-of-sight penetration for radiation through the hatchway to the door at the bottom of the well would be very small and would be negligible if the door and hatch are diagonally opposed across the well.

1. A_t area of roof = 5.76 m^2
2. $\sqrt{A_t}$ = 2.4 m
3. H-x = 2.5 m (2.8 m-0.3 m)
4. $\frac{\sqrt{A_t}}{H-x}$ = 0.96

Weight of overhead material = 1340 kg/m^2
From Fig. 21 roof contribution R = 0.025%

Wall contributions

Since the whole box is below ground surrounded by a density of earth the contribution through each of the walls can be regarded as negligible.

PROTECTIVE FACTOR
The only contribution of radiation which would reach the shelter is that passing through the roof

$$PF = \frac{100}{0.025} = 4000$$

Loss of hatch cover
Should the hatch cover be lost due to blast then some fallout could enter the well space. However, since the entrance is furnished by a flight of steps (probably concrete) then the distribution of fallout throughout the well space would be subject to a number of simplifying assumptions:

1. Hatchway has been taken as 900 x 1350 mm = 1.215 m^2.
2. Fallout is distributed over 1.215 m^2 of steps at an average height of about 1.5 m above floor level.
3. From Fig. 24 using $\sqrt{A}$ = 2.4 m and interior wall weight of 575 kg/m^2 gives contribution = 0.05%.

   The effective wall length for this contribution is only 1.35 m from a total 2.4 m consequently the contribution is reduced to 0.025%. This is further reduced to at least 0.01% due to a shielding factor from the outside wall of the shelter.
4. From Fig. 22 using $\sqrt{A}$ = 2.4 m and wall weight of 575 kg/m^2 gives a wall contribution of 0.8%.

   Again the effective wall length is 1.35 m from a total of 2.4 m, consequently the contribution is reduced to 0.45%. This contribution is further reduced by shielding to about 0.22% and then allowing that only 0.6 m of wall (of total height 2.1 m) is above fallout level this further reduction gives 0.063% as the final exposed wall contribution.
5. Addition of the two wall contributions calculated in 3 and 4 above gives overall wall contribution = 0.073%

PROTECTIVE FACTOR
R% = 0.025
G_T% = 0.073
R + G_T = 0.098

$$PF = \frac{100}{0.098} = 1020$$

Chapter 3

Structural design of domestic nuclear shelters

General approach to structural design for blast resistance 3.1

In addition to providing protection against thermal and nuclear radiation, purpose-built nuclear shelters should be designed to resist the air blast effects of nuclear explosions.

Shelters are usually placed below ground so that the effects of blast are reduced, although comparable levels of blast (and fallout) protection can be obtained above ground by using thicker elements. Where structural elements are required to sustain relatively large direct blast loads they need to be of heavy ductile construction e.g. reinforced concrete. However, structures constructed of thin-walled materials such as glass reinforced plastic (GRP) or thin metal sheeting can also be used in shelters, but their ability to withstand blast loading depends on their shape, how carefully they have been manufactured and their interaction with the earth cover. Spheres or similar shapes are the most effective but special attention must be given to weak points such as joints and entrances. Thin walled lightweight structural shells obviously offer little protection against radiation, and need to be combined with dense cover to obtain radiation protection.

The effects of blast loading are reduced significantly when shelters are deeply buried (i.e. when the earth cover is equal to or greater than about half the width of the shelter) as the overpressure is attenuated with depth and the soil acts as an arch above the shelter and takes part of the vertical load.

⇒ "EARTH ARCHING" FACTOR!

This chapter sets out guidelines for the structural design of surface or shallow buried rectangular domestic shelters constructed of reinforced concrete, or steel plate for overpressures up to 3 atmospheres (315 kPa or 45 psi), and provides a simplified dynamic design method. Above this overpressure other factors will need to be taken into consideration. Lightweight flexible building material such as GRP or thin metal sheets etc. and the design of deeply buried shelters are not covered in this book as further work and research has to be carried out before simple design rules can be given. Design guidance will be published in due course on these aspects of shelter design.

The design rules in this chapter have been limited to the analysis of one- and two-way spanning slabs likely to be used in rectangular shelters as this shape is considered to be the most cost effective for materials such as reinforced concrete. The general principles of dynamic analysis covered can be used for shelters of other shapes e.g. cylinders, arches, spheres etc. The method of analysis presented is not mandatory and the design engineer can use other appropriate methods.

It is recommended that the structural design and construction of shelters, designed for blast loading, should be supervised by a chartered structural or civil engineer experienced in structural design and practice.

Simplified dynamic blast design 3.2

Basic principles of blast-resistant design of ductile structural elements 3.2.1

The ultimate load capacity of a ductile structural element subjected to blast loading can be determined by considering its capability of sustaining external load by relatively large plastic deformations. The design rules in this guide will limit the magnitude of the plastic deformations and thus the level of damage to the structural elements to a condition of moderate damage, where there will be considerable yielding of steel and cracking of concrete, but no significant impairment of the resistance to further loading. (REPEATED BLASTS)

Chapter 5
Indoor kit shelter design

⇒ 1941 "MORRISON TABLE SHELTER" OF WW2!

General 5.1

This chapter gives information about an indoor shelter suitable for erection in homes that have basements or rooms that can be converted into a fallout room. It can be used as the 'inner refuge' referred to in the Home Office booklet *Protect and Survive* and anybody considering purchasing or using such a shelter should read *Protect and Survive* and be totally familiar with its contents.

The shelter will accommodate two adults and two small children. Two or more shelters can be placed together to gain more shelter area.

It should be stored in a clean dry place, ready for erection if required, *and could be used for other purposes, e.g. a workbench in a garage or garden shed.*

Shelter details 5.2

The indoor kit-type shelter is shown in Fig. 64.

A specialist steelwork fabricator will need to cut, weld, paint and drill bolt holes for the steel parts. However, once the units have been manufactured the shelter can be erected by unskilled labour. (Two persons two hours each.) Steelwork shop fabrication drawings are given in section 5.11, a steelwork specification in 5.10 and a guide to putting up the shelter in 5.12.

The basic unit has been designed to be capable of sustaining the debris load resulting from the complete collapse of a typical two-storey house, and when surrounded with brickwork, sandbags or other protective materials it will provide good protection against fallout.

Location of shelter 5.3

Where the shelter can be used 5.3.1

In two-storey houses and the lower floors of blocks of flats of substantial reinforced concrete or steel-framed construction, in areas where the density of building is comparatively low.

Where the shelter should not be used 5.3.2

1. Houses that have more than two storeys.
2. On the upper floors of houses or any ground floor that has a basement directly below it.
3. Blocks of flats having load bearing brickwork, blockwork or precast concrete panel construction.
4. The top two floors of a block of flats.
5. Lightly clad buildings.

Location of shelter in fallout room 5.4

As explained in *Protect and Survive* the shelter should be placed within the fallout room. Choose the place furthest from the outside walls and from the roof, or the room which has the smallest amount of outside wall or openings. The entrance should be positioned facing a solid internal wall wherever possible (see Fig. 65). A gap of 600 mm should be left between the outside of the fallout protection around the shelter and the walls of the fallout room to facilitate emergency escape.

The shelter should be placed on the most solid base available. When the shelter is to be placed on a suspended ground floor, this floor may require strengthening by providing additional piers, walls or props to support the floor joists.

5.5

Protecting the shelter against fallout radiation

Fallout protection to the shelter can be obtained by surrounding it with dry-laid brickwork, blockwork, sandbags, or heavy furniture filled with sand, earth or books (see Figs. 66 and 67). Recommended thicknesses of shielding materials are given in the following table:

Fig. 61 ***Recommended thicknesses of shielding materials***

	Thicknesses		
	To sides		To top
	Sides facing external walls	Sides facing solid internal walls	
Brickwork	$1\frac{1}{2}$ bricks (343 mm)	1 brick (225 mm)	4 courses bricks (260 mm)
Dense blockwork	$1\frac{1}{2}$ blocks (330 mm)	1 block (225 mm)	3 courses blocks (300 mm)
Sandbags	350 mm	250 mm	300 mm

If bricks or blocks are used they should be dry-laid, but closely packed and bonded so as to stagger the joints as much as possible. Suggested bonding is shown in Fig. 68.

Fallout room

External windows and doors in the room containing the shelter should be blocked up with material of the same weight as the surrounding wall. A 600 mm by 600 mm dry-laid area should be left within the blocked-up area to provide an escape exit.

For shelters protected as described, protective factors are given in the following table:

Fig. 62 ***Approximate protective factor***

House type	Protective factors	
	House with all exterior windows blocked	House with exterior windows blocked plus shelter and bricks
Terraced: traditional	15	260
modern	11	140
Semi-detached: traditional	12	210
modern	9	130
Detached: traditional	10	180
modern	8	110

5.6

Provision of emergency escape tunnel

Materials

Use tables, doors and other items of heavy furniture to form an emergency escape tunnel. As for *ad hoc* shelters, other structural commodities might be utilised for building escape tunnels. Fig. 69 shows how scaffold poles could be used for the purpose.

Location of escape tunnel

The escape route should be planned so that it emerges near to an opening in an external wall. If external openings are blocked up, a weaker escape knock-out area (e.g. dry-laid bricks or blocks 600 mm by 600 mm) should be provided.

5.7

Tools and materials required

For construction

16 mm and 10 mm spanners (1 open, and 1 ring, of each).
Steel lever for lining up holes.
Work gloves.

For shelter

Recommended quantities of materials for fallout protection are given in the following table. (Figures in table for entrance shielding wall, but do not consider materials required for blocking up openings in external walls.)

Fig. 63 *Amounts of material for protection*

Distribution of material	No. of bricks	No. of blocks	Soil/earth for sandbags
$1\frac{1}{2}$-brick equivalent on 4 sides of shelter and 5 courses on top	3300	550	5.2 cu m
1 short side of shelter shielded with $1\frac{1}{2}$-brick equivalent, other 3 sides 1-brick equivalent, and 5 courses on top	2500*	420	4 cu m

*It takes four people approximately 10 hours to carry 2500 bricks from a stockpile and stack them around a shelter.

Shelter ventilation 5.8

The shelter entrance must remain open at all times to provide adequate free air passage into the shelter. If external openings have been blocked up in the room containing the shelter it is important that the door of the room should also be kept open.

Fitting out shelter 5.9

The shelter should be fitted out as described in Chapter 1 with the following additional items:
1. Heavy hand hammer
2. Crowbar
3. Masonry cold chisel
4. Wire cutters

Steelwork specification 5.10

1. Steel angle shall be metric angles to BS 4848, Part 4, 1972, or equivalent standard sections to BS 4, 1971.

2. The steel shall be grade 43 or 50 to BS 4360, 1969.

3. All fasteners are to be ISO metric black hexagon bolts and nuts to BS 4190, 1967.

4. All steel members shall be mechanically wire-brushed, then thoroughly cleaned with suitable detergent and rinsed with warm water to remove all corrosion products. When dry the element shall be primed with one coat of suitable metal primer and painted with one coat of compatible drying-oil undercoat and one coat of drying-oil finish coat all in accordance with the manufacturer's instructions.

Fabrication drawings 5.11

See Figs. 70–79

Fig. 64 ***Indoor kit-type shelter***

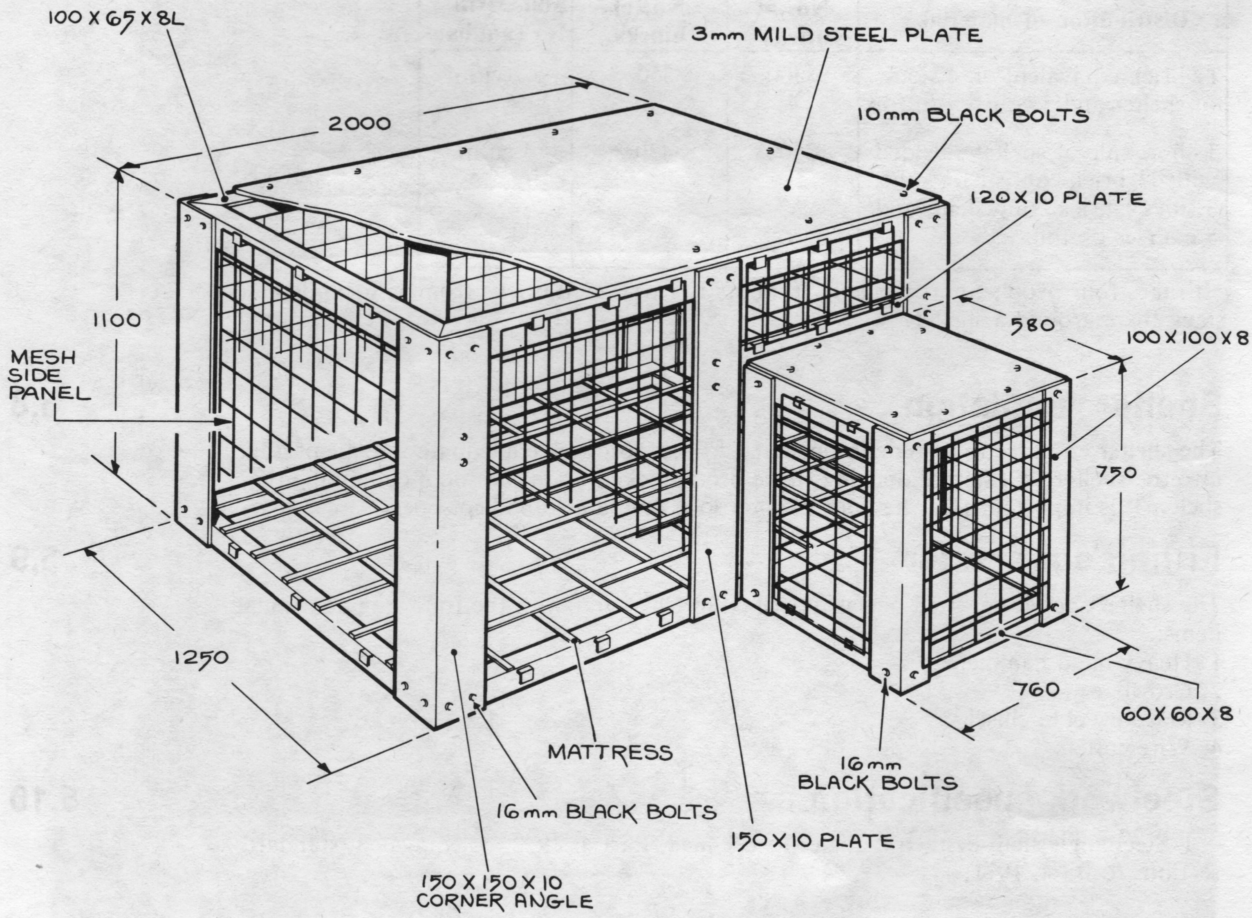


Fig. 65 ***Location of shelter***

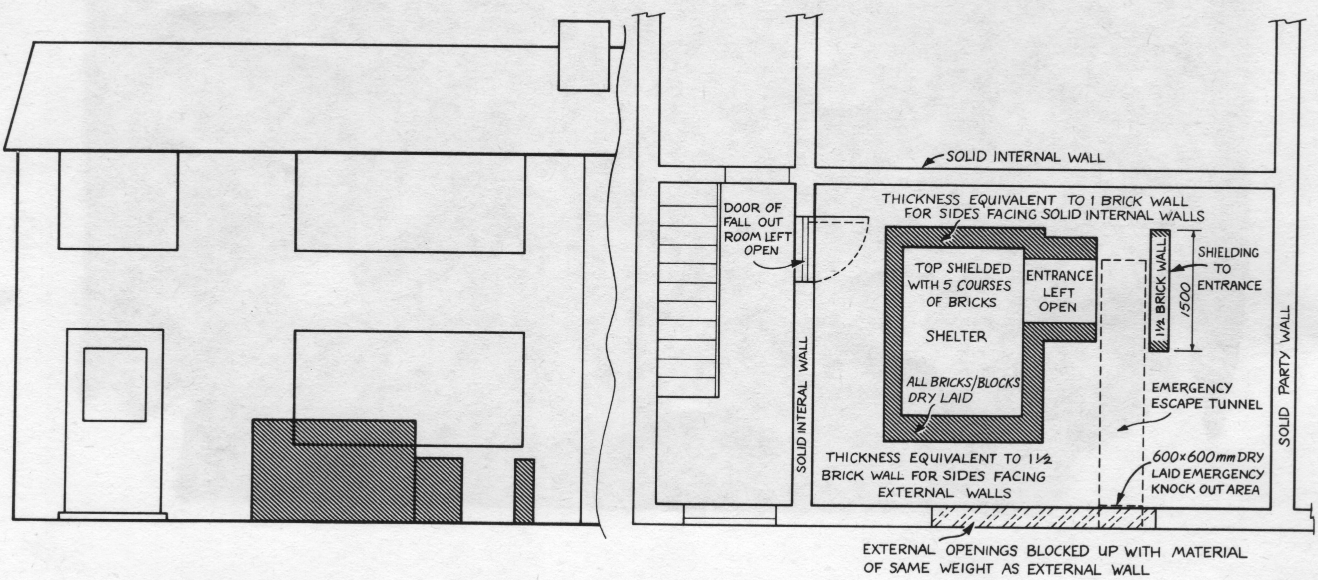
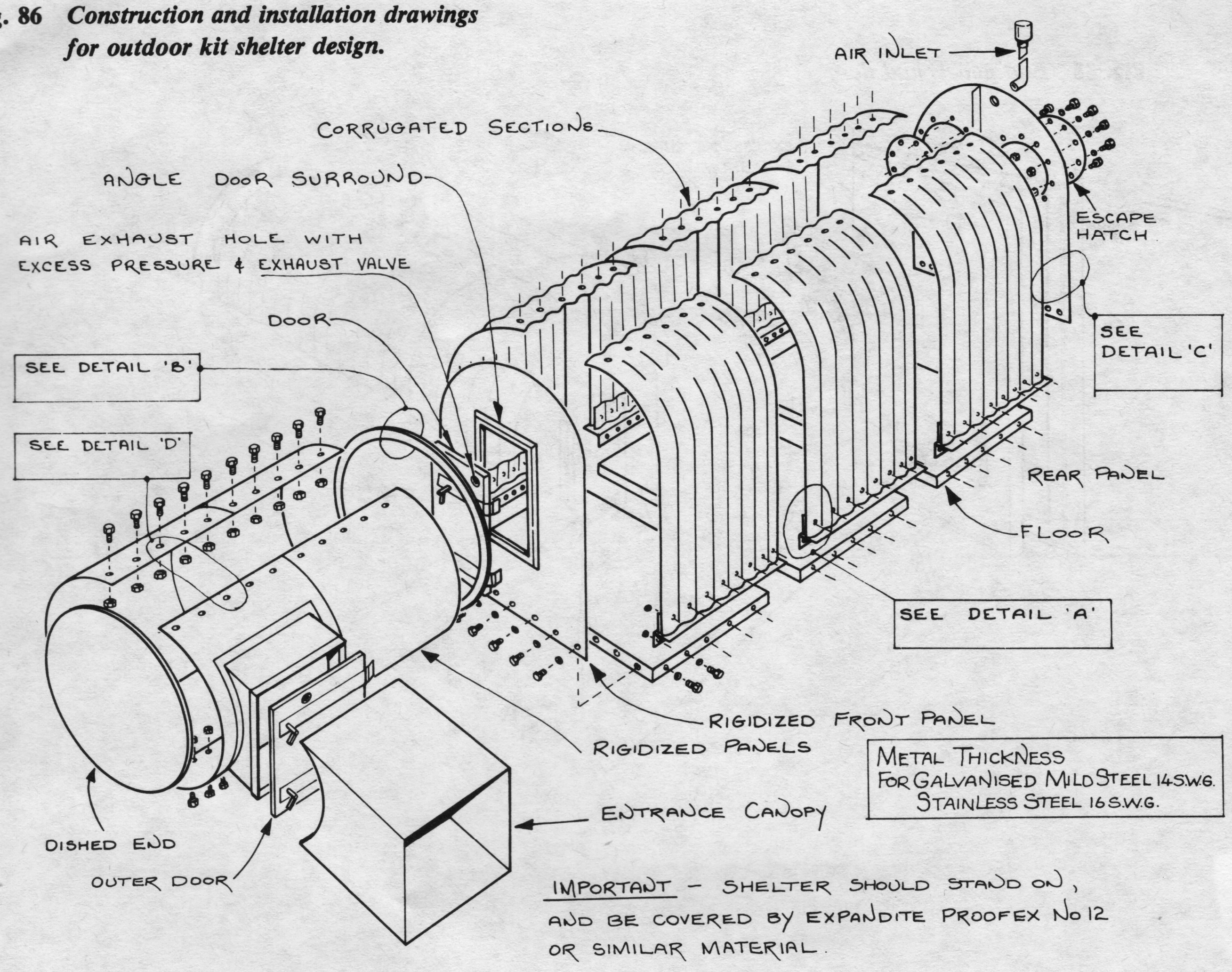


Fig. 86 ***Construction and installation drawings for outdoor kit shelter design.***



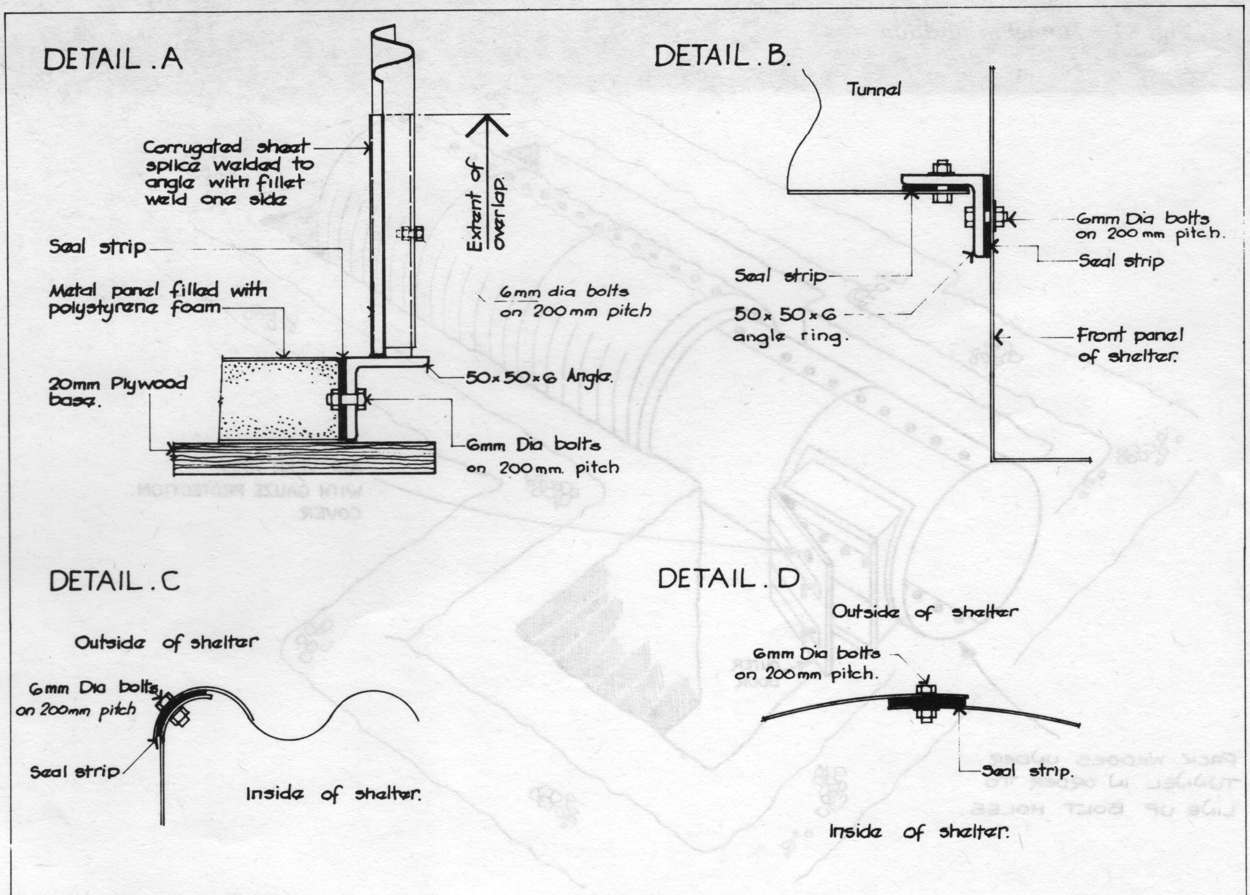
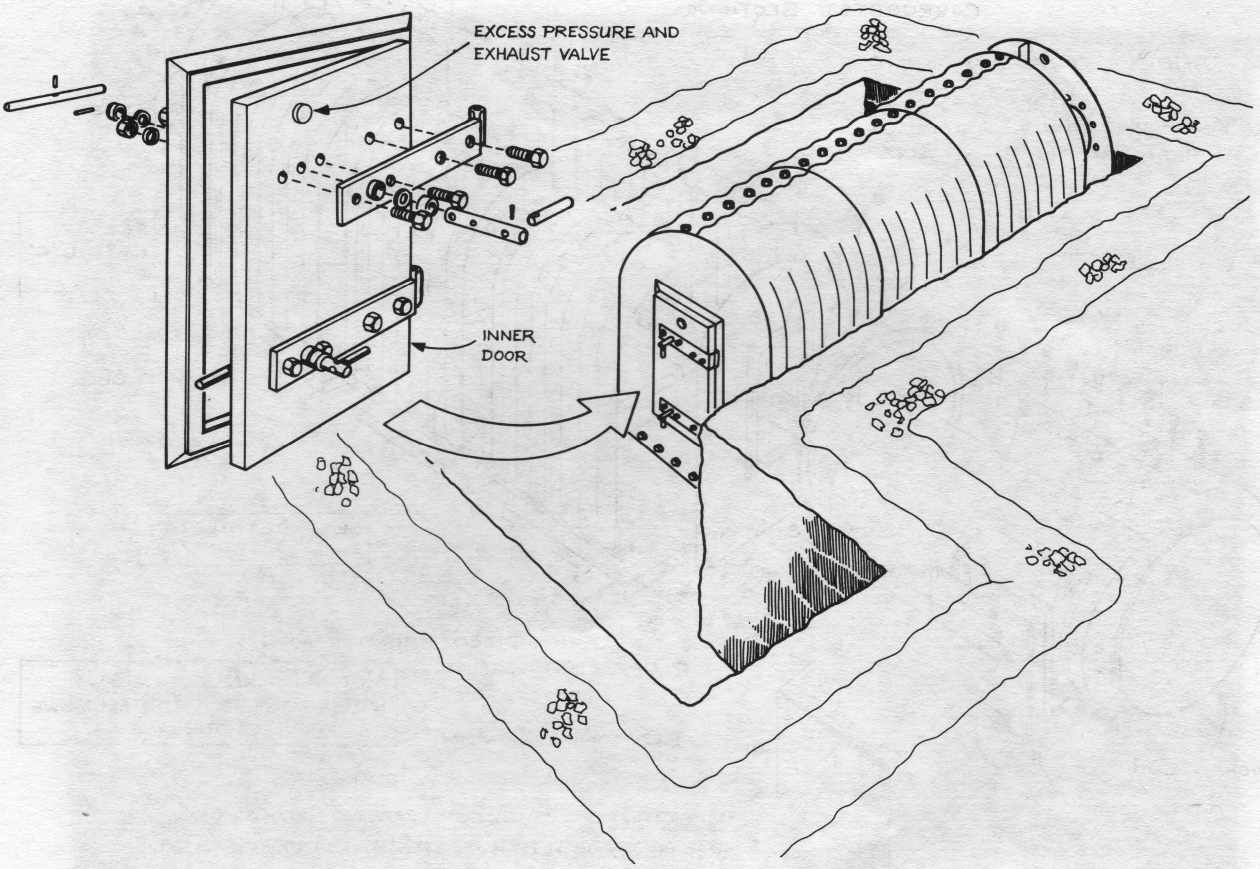


Fig. 87 ***Details***

Fig. 88 *End panels and door*



IMPROVED 1939 "ANDERSON SHELTER" OF WWII & 1952 HURRICANE NUCLEAR TEST!

Fig. 89 *Tunnel in position*

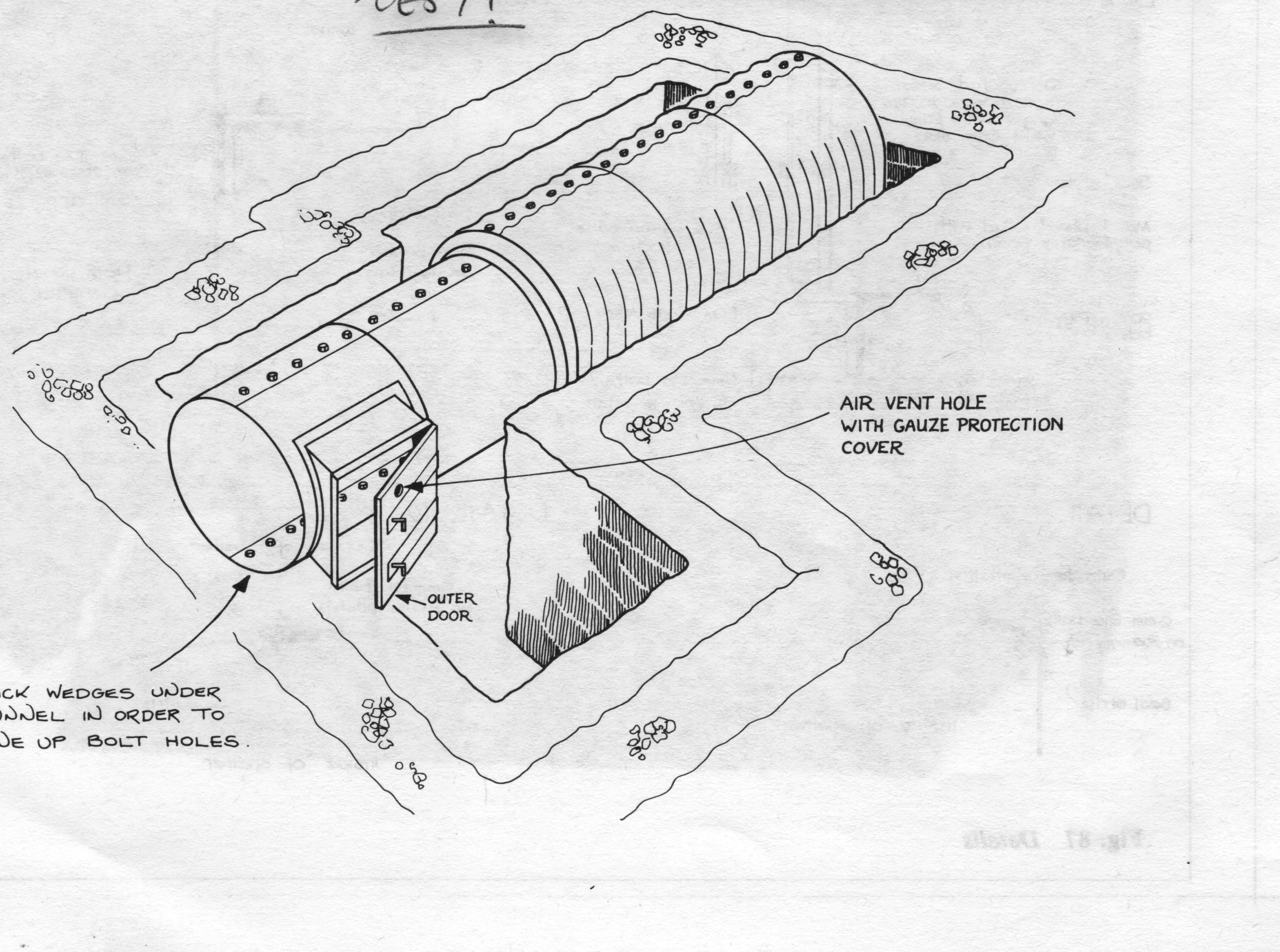


Fig. 90 ***Final construction***

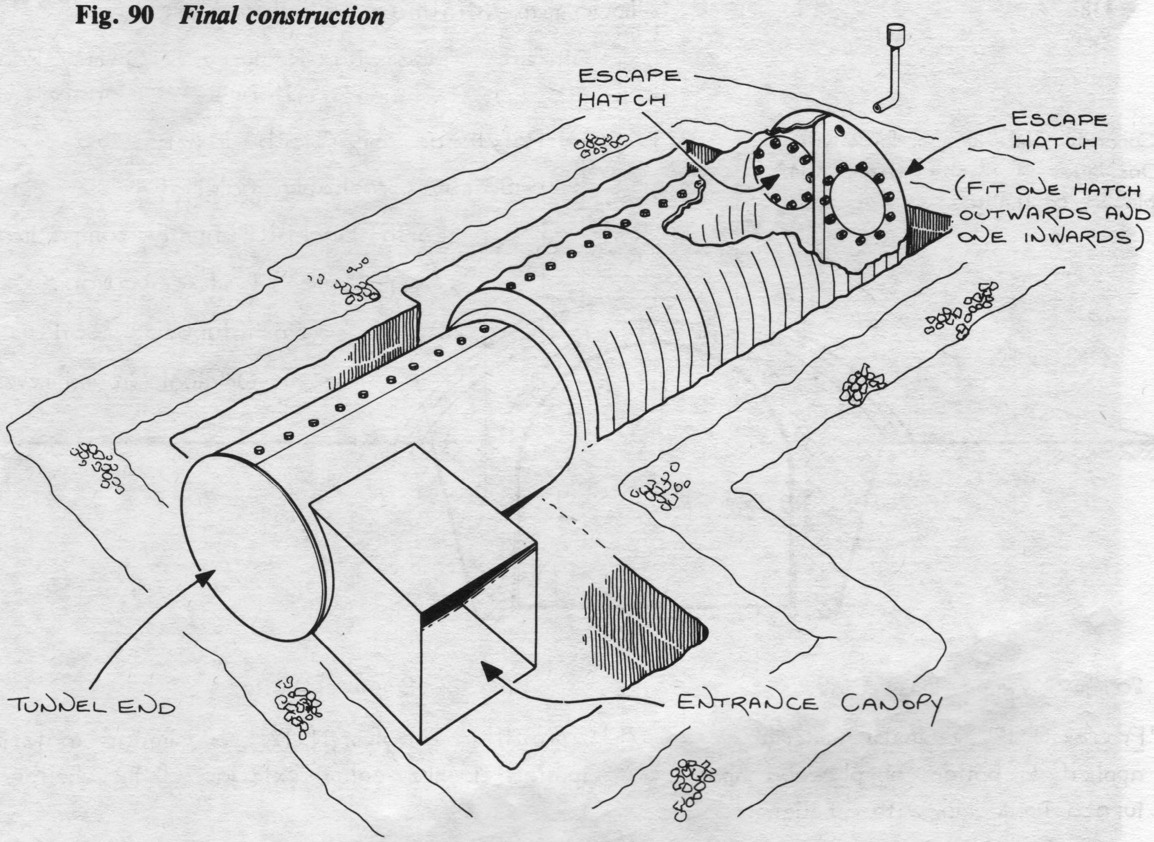


Fig. 91 ***Earth cover***

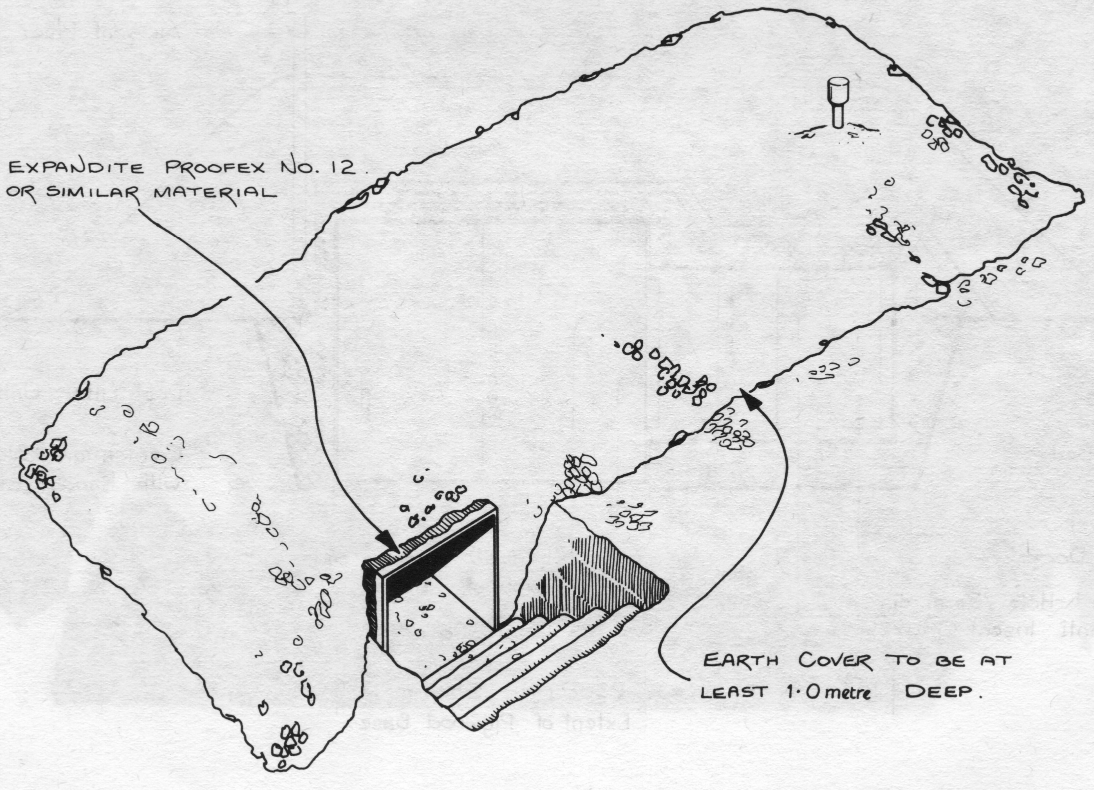
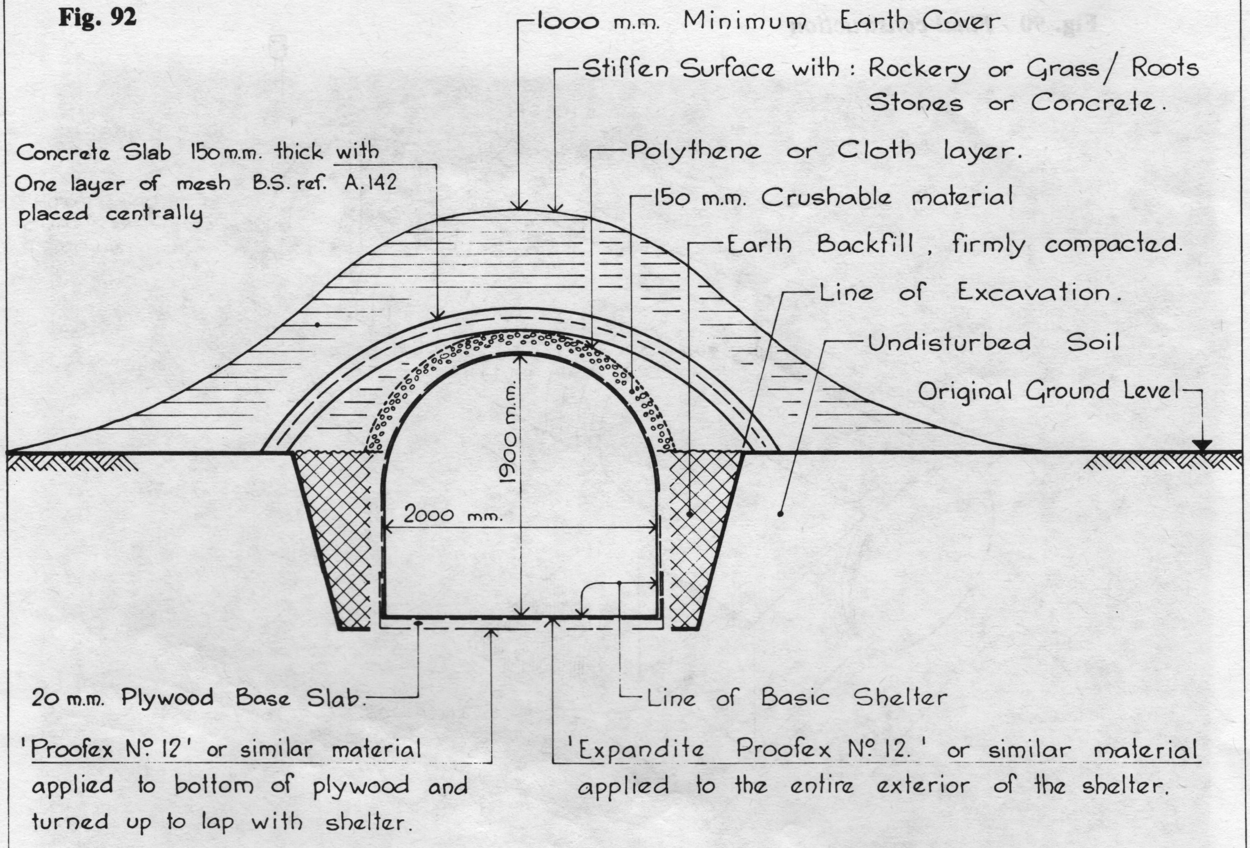
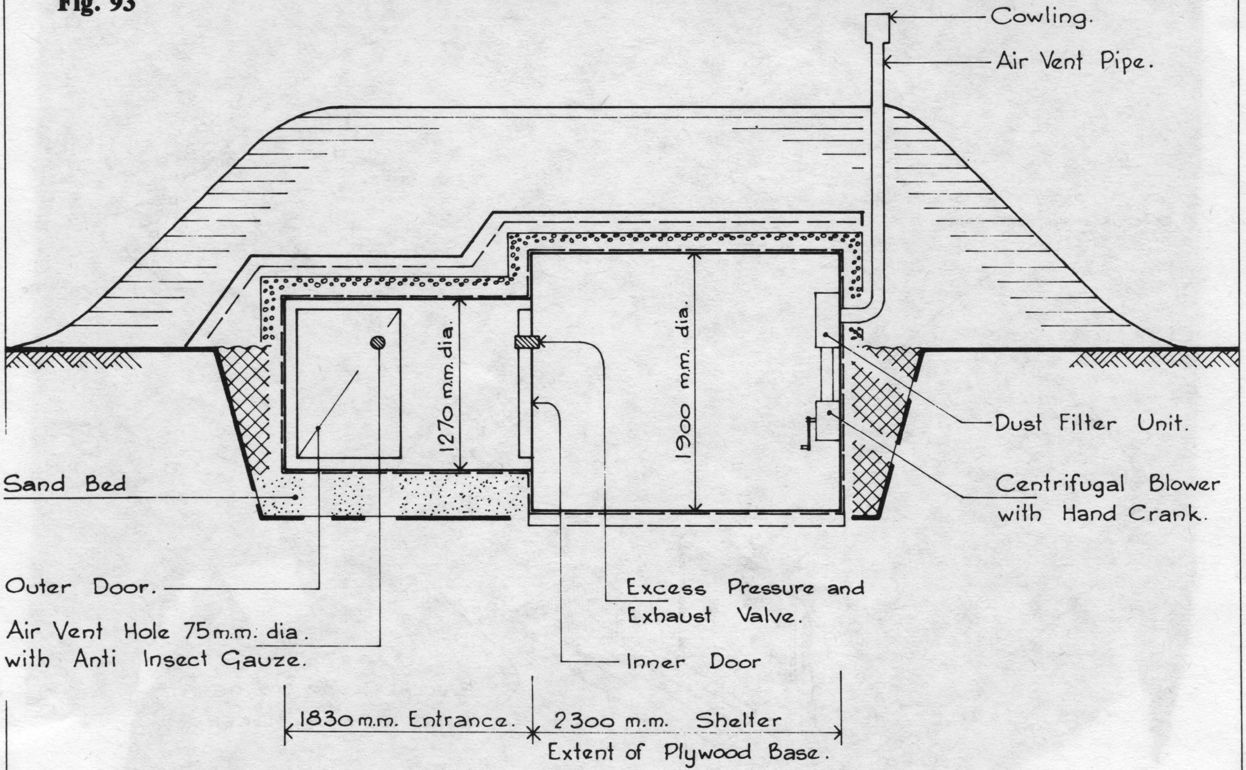


Fig. 92



TYPICAL CROSS SECTION : (FLAT BOTTOM)

Fig. 93



LONGITUDINAL SECTION : (FLAT BOTTOM)

Similar to ROC bunkers!!

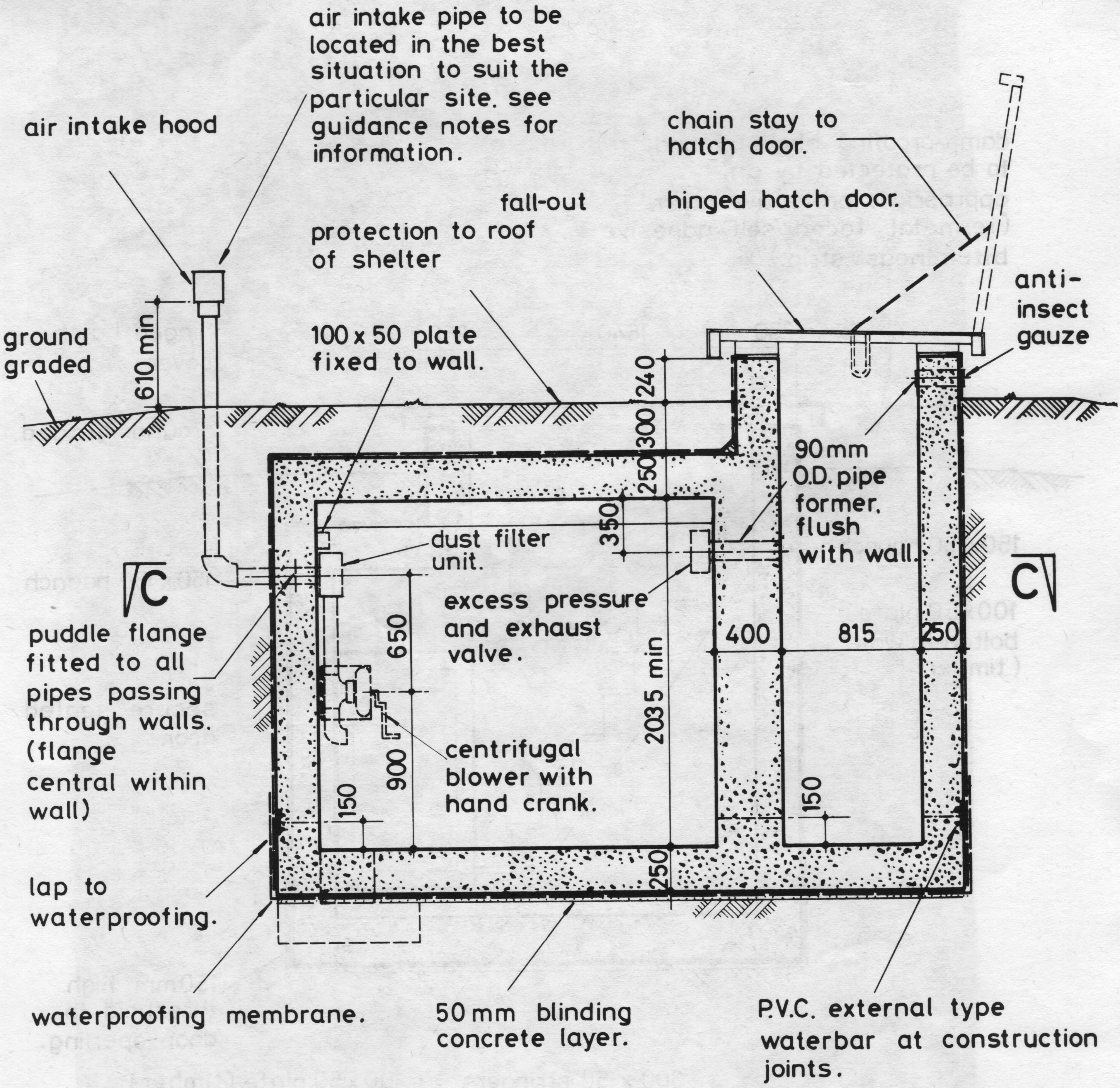


Fig. 100 *Section A–A*

> 100 psi peak overpressure nuclear-tested underground shelter (also for R.O.C.)

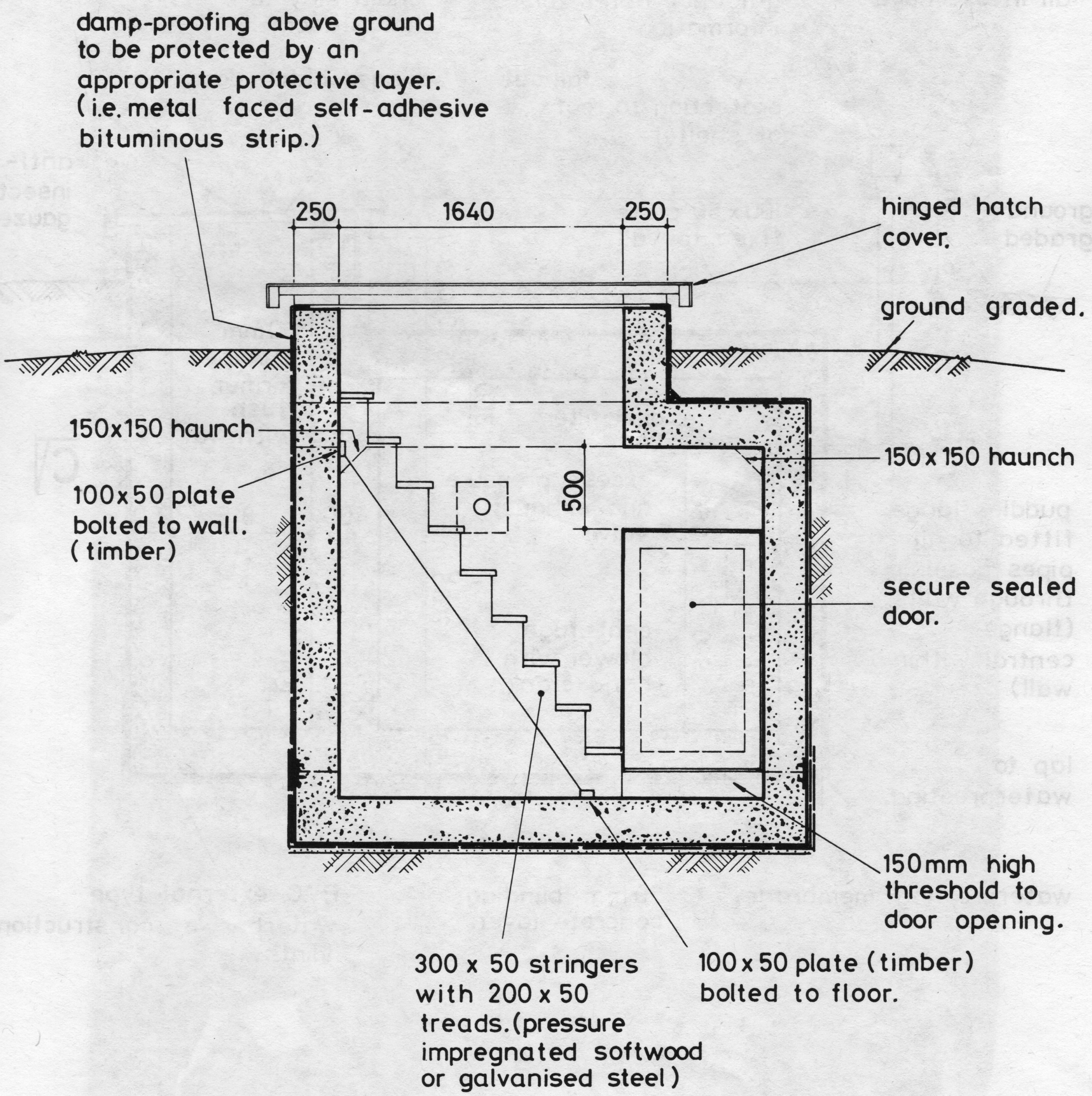


Fig. 101 ***Section B–B***

HANDBOOK OF NUCLEAR WEAPON EFFECTS

Calculational Tools Abstracted From DSWA's Effects Manual One (EM-1)

John Northrop

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HANDBOOK OF NUCLEAR WEAPON EFFECTS

1st Edition
September 1996

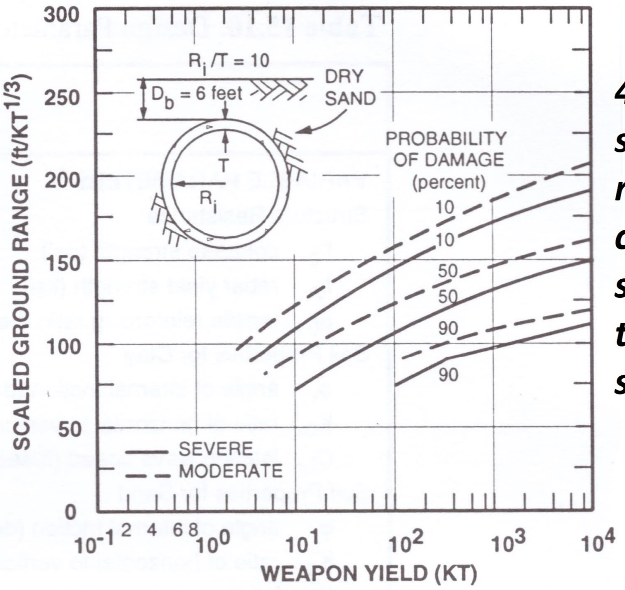

Figure 15.52. Vulnerability Curves for a Horizontal Cylinder, Aspect Ratio $R_i/T = 10$ (Structure Category 15.3.18) Buried in Dry Sand.

4500psi stress reinforced concrete silos and tube shelters

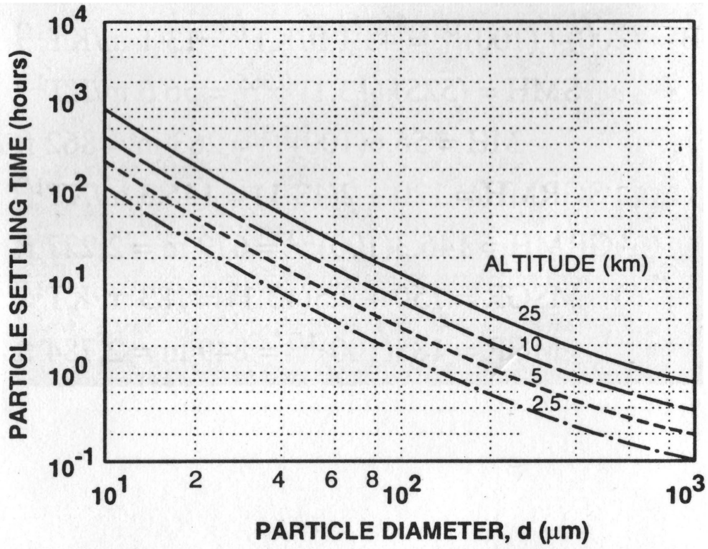

Figure 4.3b. Particle Settling Time(s) in Still Air Versus Small Particle Diameter (micron).

Figure 15.62. Basic Vulnerability Chart for Tunnels in Rock.

LIMITS OF SURVIVABILITY IN GRANITE FOR 1 MT

TYPE OF LINING	SLANT RANGE, R (feet)
SPECIAL COMPOSITE	600 – 700

Table 14.1. Combat Ineffectiveness for Personnel in an Open Two-Man Foxhole (2 x 6 x 4.5 feet) Side-On to Blast Wave.

COMBAT INEFFECTIVENESS (%)	WEAPON YIELD (KT)					
	0.01	0.1	1	10	100	1,000
	PEAK INCIDENT OVERPRESSURE (psi)					
99	52	38	38	38	38	38
50	37	29	29	29	29	29
1	25	21	21	21	21	21

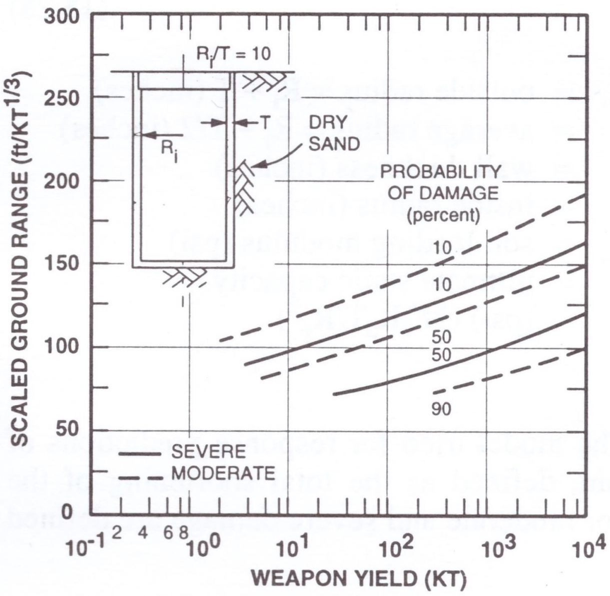

Figure 15.60. Vulnerability Curves for a Vertical Cylinder, Aspect Ratio $R_i/T = 10$ (Structure Category 15.3.24) Surface Flush in Dry Sand.

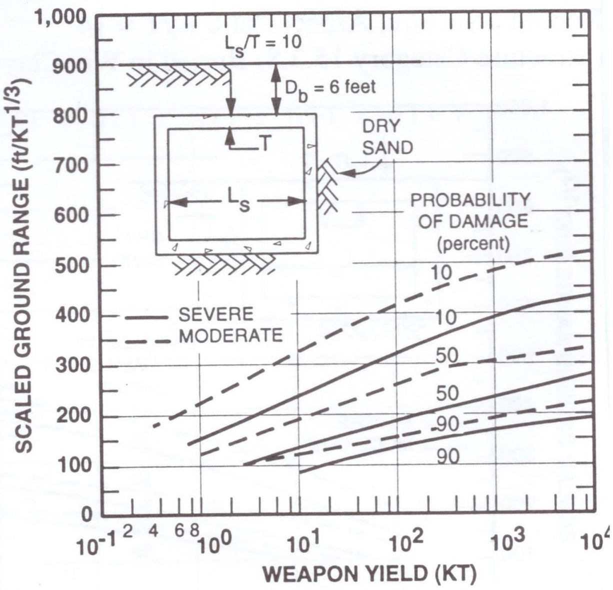

Figure 15.35. Vulnerability Curves for a Flat-Roofed Structure, Aspect Ratio $L_s/T = 10$ (Structure Category 15.3.3) Buried in Dry Sand.

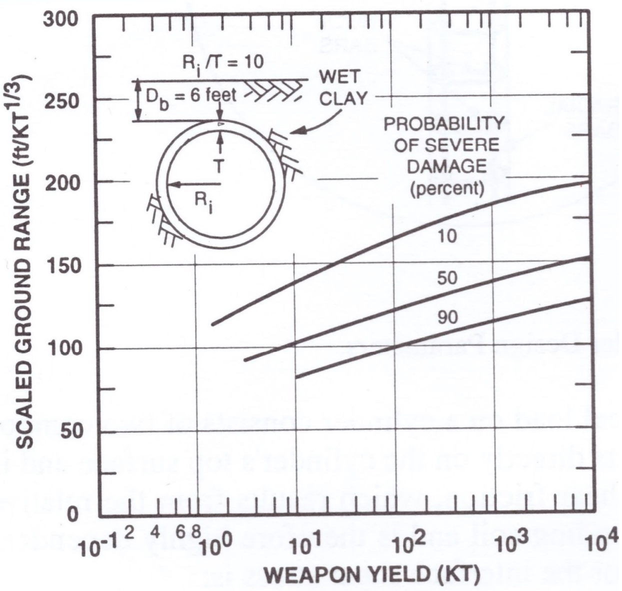

Figure 15.55. Vulnerability Curves for a Horizontal Cylinder, Aspect Ratio $R_i/T = 10$ (Structure Category 15.3.21) Buried in Wet Clay.

Table 15.15. Field Fortification Damage Criteria.

STRUCTURE CATEGORY	STRUCTURE TYPE	STRUCTURE DESCRIPTION	DAMAGE DESCRIPTION SEVERE	MODERATE	LIGHT
15.7.1	MGEs	Machine-gun emplacement, 7 x 7-foot framework extending 2 feet above original ground surface, has open firing ports and open trench entrance; 3- to 5-foot mound of earth cover extends down to the surface except at openings.	Caps and posts broken, large displacement and disarrangement of timbers, revetment failure.	Some caps and posts broken, moderate displacement, some revetment failure.	Damage to minor components only, slight displacement, occasional revetment failure.
15.7.2	CPs	Command post and personnel shelter, modular sections 6 x 8 feet with top 3 to 5 feet below the ground surface; earth covered, and covered trench entrance.	Caps and posts broken, large displacement and disarrangement of timbers, revetment failure.	Some caps and posts broken, moderate displacement, some revetment failure.	Damage to minor components only, slight displacement, occasional revetment failure.
15.7.3	Shelters	A hardened frame/fabric shelter with sealed vertical entryway, buried with at least 4 feet of cover.	Complete collapse of shelter frame and total filling of shelter by overburden.	Large deflections of frame and entryway, partial filling of shelter.	Minor displacement of shelter and entryway.
15.7.4	Trenches	Unrevetted trenches and foxholes with or without light cover.	At least 50 percent filled with earth.	At least 20 percent but less than 50 percent filled with earth.	Less than 20 percent filled with earth.

Table 15.16. Machine Gun Emplacement Vulnerability Levels.

PERCENT PROBABILITY OF DAMAGE	LEVEL OF DAMAGE LIGHT	MODERATE	SEVERE
	Peak overpressure (psi)		
10	15	35	45
50	25	50	65
90	35	75	100
	Peak dynamic pressure (psi)		
10	1.3	10	20
50	2	15	30
90	3	23	45

Table 15.17. Command Post and Personnel Shelter Vulnerability Levels for Peak Overpressure (psi).

PERCENT PROBABILITY OF DAMAGE	LEVEL OF DAMAGE LIGHT	MODERATE	SEVERE
10	20	35	40
50	30	50	60
90	45	75	90

Table 15.18. Hardened Frame/Fabric Shelter Vulnerability Levels for Peak Overpressure (psi).

PERCENT PROBABILITY OF DAMAGE	LEVEL OF DAMAGE LIGHT	MODERATE	SEVERE
10	20	35	40
50	30	50	60
90	45	75	90

FIG. 2.3: 1 kt free air burst (sea level air density) peak overpressure

$P = 3.04 \times 10^{11} / R^3 + 1.13 \times 10^9 / R^2 + 5 \times 10^6 /^{R}$ Pascals +/-15%, R in metres

for surface bursts, set $R = 2^{-1/3}$

FIG. 2.6: 1 kt free air burst (sea level air density) total overpressure impulse

$I_p = 10^6/R$ Pa-sec +/-20%, R in metres.

FIG. 2.7: 1 kt free air burst (sea leve air density) total dynamic pressure impulse

$I_q = 10^9 / R^{2.5}$ Pa-sec +/-20%, R in meters (valid: R > 150m).

PREFACE

At the time of publication of the Defense Special Weapons Agency's (DSWA) eighth edition of *Effects Manual One** (*EM-1*), which was completed in 1993, it was recognized that its easy use would be limited by both its length and its classification. This work, *EM-1 Technical Handbook*, addresses those limitations. It is designed for the engineer who has a working knowledge of nuclear weapon effects and, thus, does not need the extensive tutorial sections of the basic *EM-1*. It includes algorithms, graphs, and tables required to make approximate quantitative estimates of nuclear weapon effects, along with a brief description of their use.

Of the twenty-two volumes of *EM-1*, five were judged inappropriate for this handbook, either as a result of their extensive classified database or because they were almost entirely qualitative and tutorial. In addition, Volume 1, containing synopses of the other volumes, has been omitted. The chapter numbering in this handbook maintains the nomenclature of the main *EM-1*, with consequent gaps for the omitted volumes. Most of the Sample Problems from *EM-1*, judged helpful in understanding the application of the algorithms, have been included but in a more compressed form. Other sacrifices, primarily in type font and figure size, have been made to allow the handbook to be printed in a single volume. Additionally, to save space, all the primary source references in *EM-1*, both for specific data used as well as extensive bibliographies, have been deleted in this handbook. Readers requiring more detailed information are referred to the original *EM-1*, for which all except Volumes 1, 3, and 13 are classified.

The actual publication date of each *EM-1* volume is indicated below. Because of the lengthy writing, review, and publication process, the actual age of the technology provided is approximately five years before this date. For the current status of the contents of any *EM-1* chapter, write to the Weapons Effects Division, Defense Special Weapons Agency, 6801 Telegraph Road, Alexandria, VA 22310-3398. Since the Editor of this handbook has simply abstracted the material from the basic multi-volume series, with some liberties taken in compressing text, the following authors of the source volumes of *EM-1* deserve full credit:

Vol. 2: D.C. Sachs, E. Martin (Kaman Sciences); L. Kennedy, G. Schneyer, J. Barthel, T. Pierce, C. Needham (Maxwell Laboratories); and J. Keefer, N. Ethridge; (1985).

Vol. 3: C.K.B. Lee, L.P. Mosteller, and T.A. Mazzola (Logicon RDA); E.J. Rinehart, (DSWA), A.V. Cooper, and S.H. Schuster (California Research and Technology Corp.); (1992).

Vol. 4: J.E. Cockayne and D.P. Bacon (SAIC); T.A. Mazzola (Logicon RDA); M. Rosenblatt (The Titan Corporation), and J.A. Northrop, Editor (S-Cubed); (1992).

Vol. 5: R.M. Barash, J.A. Goertner, and G.A. Young (Naval Surface Warfare Center); C.B.K. Lee (Logicon RDA); B.B. LeMehaute (University of Miami); and J.P. Moulton (Kaman Sciences); (1991).

Vol. 6: J.R. Keith and D.C. Sachs (Kaman Sciences); (1985).

Vol. 7: D. Steel, J.R. Keith, H.D. Bos, and E.J. Plute, Jr., (Kaman Sciences); H.C. Lindberg (APTEK, Inc.); (1987, 1993).

Vol. 8: D.C. Kaul, F.Dolatshahi, W.A. Woolson, and W.Scott (SAIC); H.G. Norment (ASI); (1990).

Vol. 9: W. Knapp and B. Gambill (Kaman Sciences); (1986).

Vol. 10: E. Quinn (Technical Integrator), J. Schlegel and W. Kehrer (Logicon RDA), C. Fore (Editor) and T. Stringer (Kaman Sciences), R. Schaefer and W. Radasky (Metatech), G. Morgan (TRW), and K. Casey and B. Stewart (JAYCOR); (1992).

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*Requests for copies of the original 22 volume Effects Manual One (EM-1) should be addressed to the Defense Special Weapons Agency, 6801 Telegraph Road, Alexandria, Virginia 22310-3398.

Vol. 11: W.A. Alfonte and E.A. Wolicki (Kaman Tempo), J.R. Srour (Northrop Corp.), and J.P. Raymond (Mission Research Corp.); (1988).

Vol. 14: M.K. Drake and W.A. Woolson (SAIC); (1993).

Vol. 15: D. Bergosian (Karagozian & Case), C.C. Deel (SAIC), and W.J. Hall (H&H Consultants); (1993).

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Vol. 21: J. Eamon, J. Keith, R. Keefe, R. Ponzini, J. Betz, J.L. Forkois, J.L. Harper, J. Hess, T. Stringer, P. Book, D. McLemore, R. Ruetenik, L. Mente, and G. Zarthaian (Kaman Sciences), W. Lee (HTI), R. Halprin and B. Strauss (MDAC), and H. Lindberg (APTEK); (1993).

Vol. 22: M. Bell, D. Breuner, P. Coakley, B. Stewart, M. Treadway, J. Sperling, E. Wenaas, and A. Wood (JAYCOR); (1990).

The editor wishes to express his thanks to Dr. C. Stuart Kelley of the Defense Special Weapons Agency for his consistent and enthusiastic support for this project, without which this handbook could not have been completed. The editor is also indebted to the technical editing (Chris Brahmstedt), graphics (Cindy Grooms, Donna LaFontain, and Will Larsen), and publication (Dianne McCune) staff at DASIAC (the Information Analysis Center supporting DSWA) for their long and patient labor in preparing this handbook for printing.

John A. Northrop
Editor
Maxwell Technologies, Inc.
September 1996

TABLE OF CONTENTS

8. NUCLEAR RADIATION PHENOMENA

8.1 Introduction. Although the radiation from nuclear explosions includes gamma rays, neutrons, beta particles, and alpha particles, only the first two elements are transported over significant distances through matter, and thus are the only ones considered in detail in this chapter. The exceptions to this are high-altitude explosions in which beta-particle phenomena occur over large distances, and direct contact with fallout in which beta particles, and to a lesser extent and only at very late times, alpha particles, may be significant.

8.2.2 Weapon Radiation Sources.

8.2.2.1 Generic Weapon Types. *EM-1* contains a complete description of 13 generic weapon types and extensive data on the atmospheric transport of their several types of radiation outputs. Table 8.4 is an abstract of four of these types. In general, the data in this handbook are the subset of the *EM-1* data for these types.

Table 8.4. Representative Types of Nuclear Weapons.

TYPE	DESCRIPTION
3	Unboosted fission implosion weapon, contemporary design
5	Boosted fission implosion weapon, modern design
8	Thermonuclear secondary
13	Enhanced radiation thermonuclear secondary

8.2.2.3 Gamma-Ray Sources. For most weapon designs (Table 8.6), the range of gamma-ray production efficiency as a percent of total yield ranges from 0.1 to 0.5 percent, with the larger gamma yields attributed to those weapons that are physically the smallest. Average gamma-ray energy depends more on the origin of the weapon yield (fission or fusion) and the physical size of the weapon than on the yield itself. Small weapons and those that obtain a large fraction of their yield from the fusion process tend to have the highest average gamma ray energies.

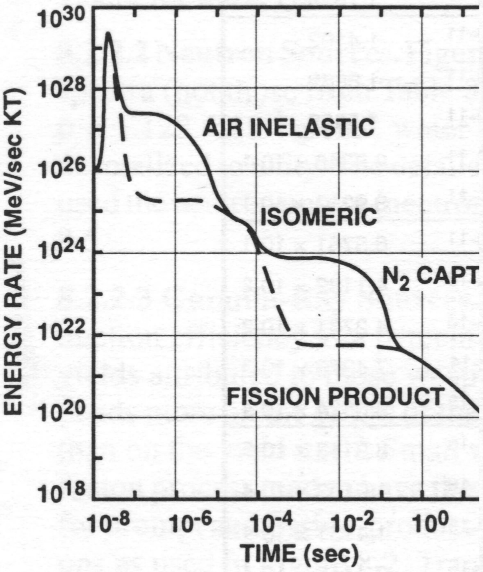


Figure 8.1. Idealized Time Dependence of the Gamma-Ray Output from a Large Yield Explosion, Normalized to 1 KT.

Table 8.5. Neutron Source Spectra and Output for Types 3, 5, 8, and 13.

ENERGY RANGE (MeV)		NEUTRONS PER MeV			
UPPER	LOWER	SOURCE 3	SOURCE 5	SOURCE 8	SOURCE 13
1.49×10^{1}	– 1.22×10^{1}	8.85×10^{-5}	9.47×10^{-3}	1.65×10^{-2}	1.42×10^{-1}
	NEUTRONS PER KT	2.70×10^{23}	3.38×10^{23}	1.95×10^{23}	1.77×10^{24}

Table 8.6. Weapon Gamma-Ray Output.

WEAPON TYPE	TOTAL GAMMA-RAY ENERGY [a] (MeV/KT)	AVERAGE GAMMA-RAY ENERGY (MeV)	PEAK GAMMA-RAY OUTPUT RATE [a, b] (MeV/nsec-KT)
3	9.80×10^{22}	1.50	4.92×10^{21}
5	1.04×10^{23}	1.61	5.22×10^{21}
8	$3.55 \times 10^{23} \times W^{-0.29}$	1.63	$1.79 \times 10^{22} \times W^{-0.29}$
13	6.70×10^{23}	2.00	3.37×10^{22}

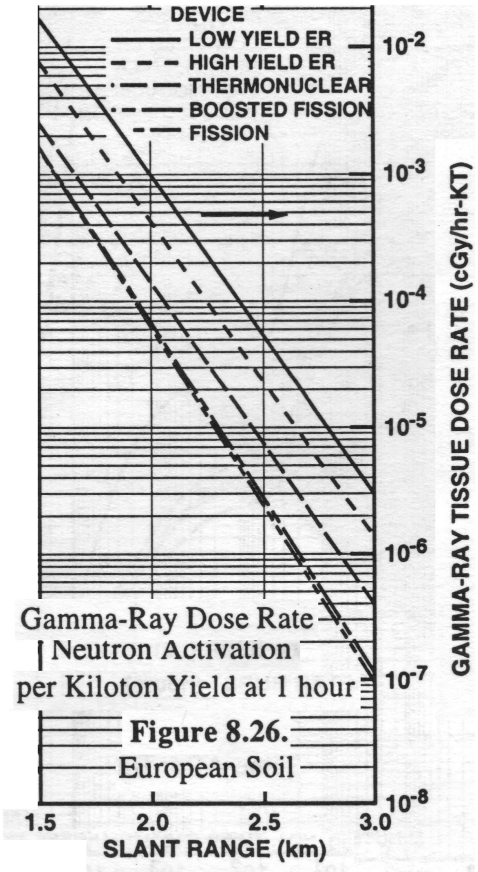
Notes: a - W is yield in kilotons.
b - Illustrative values based on a hypothetical prompt gamma-ray pulse duration of 20 nsec

Table 8.10. Height of Burst and Yield Range for Generic Device Types.

Device Type	Data HOB (meters)	HOB Range (meters)	Yield Range (KT)
Enhanced Radiation (ER) (13)			
Low Yield	75	50 - 100	1 - 5
High Yield	200	100 - 300	5 - 15
Thermonuclear (8)	200	150 - 500	10 - 500
Boosted Fission (5)	160	60 - 300	1 - 20
Fission (3)	150	60 - 300	0.5 - 15

Table 8.12. Critical Target Composition of Soil Types.

	Percent by Weight				
Soil Type	Sodium	Silicon	Aluminum	Maganese	Iron
Mojave	3.30	23.5	9.57	0.14	7.31
European	1.39	28.3	4.05	0.12	1.98
Nevada Area 7	0.80	25.3	7.70	0.07	1.52
Dade County	0.12	45.4	0.03	0.01	0.06



Gamma-Ray Dose Rate Neutron Activation per Kiloton Yield at 1 hour

Figure 8.26. European Soil

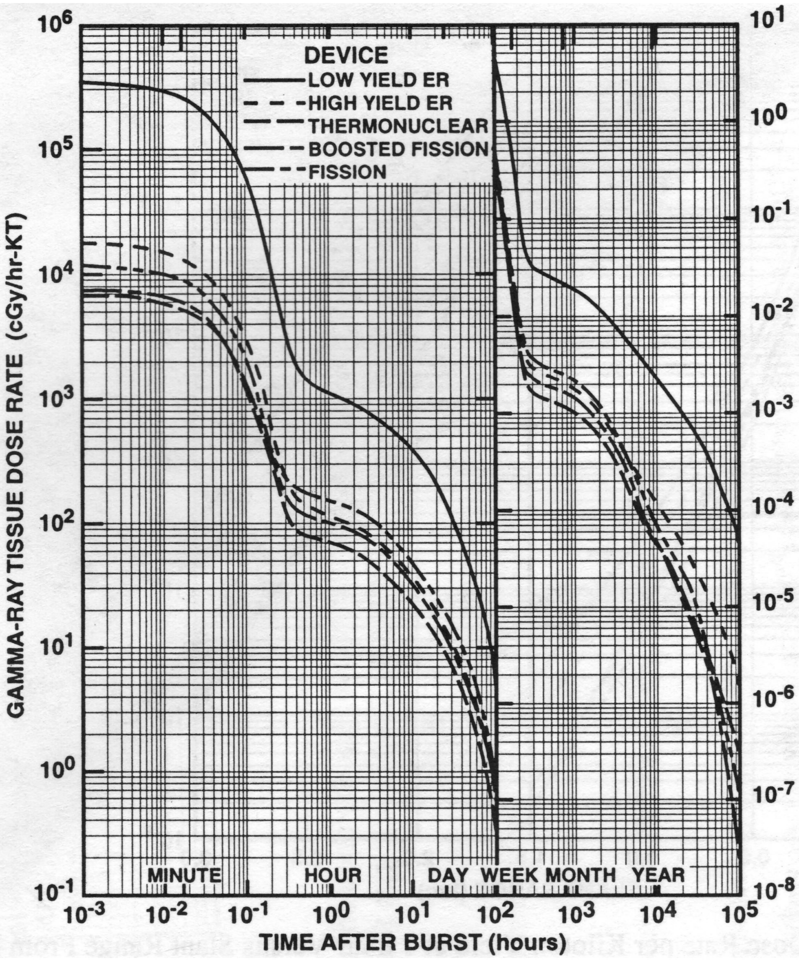


Figure 8.28. Gamma-Ray Dose Rate per Kiloton Yield at Ground Zero Neutron Activation of European Soil for Various Nuclear Weapon Types.

Figure 8.45. Fraction in Main Cloud.

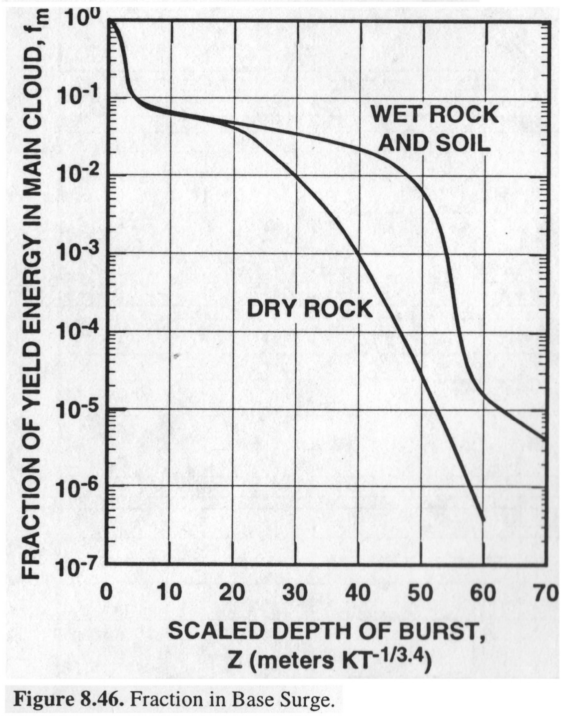
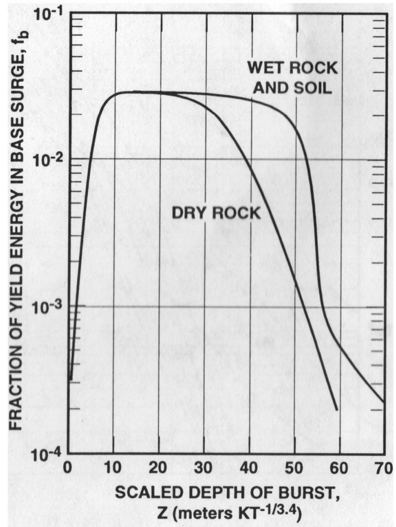


Figure 8.46. Fraction in Base Surge.



4.2.3 Dust Mass Loading.

Surface Bursts (SHOB < 5 ft/KT$^{1/3}$). The collected and analyzed soil and saltwater particles provide estimates of the lofted mass in nuclear clouds. The empirical relation from combining the soil and saltwater data for scaled mass in stabilized surface burst clouds is:

$$M_{SB}/W = 0.62\ W^{-0.11}, \qquad (4.8a)$$

where W is the yield in KT and M_{SB} is in KT = 10^9 grams, or

$$M_{SB}/W = 0.29\ W^{-0.11}, \qquad (4.8b)$$

where W is in MT and M_{SB} is in Mt = 10^{12} g.

Airbursts (SHOB ≥ 5 ft/KT$^{1/3}$). The experimental mass loading data have large scatter. DICE/TASS calculations have been used with these experimental data to generate the following approximated main cloud mass loading relationship with SHOB.

$$M/W(KT/KT) = 0.25\ \exp(-SHOB/75) + 0.04(1-SHOB/800) \qquad (4.9a)$$

for $5 \le SHOB \le 800$ ft/KT$^{1/3}$, and

$$M/W = 0 \text{ for } SHOB > 800 \text{ ft/KT}^{1/3}. \qquad (4.9b)$$

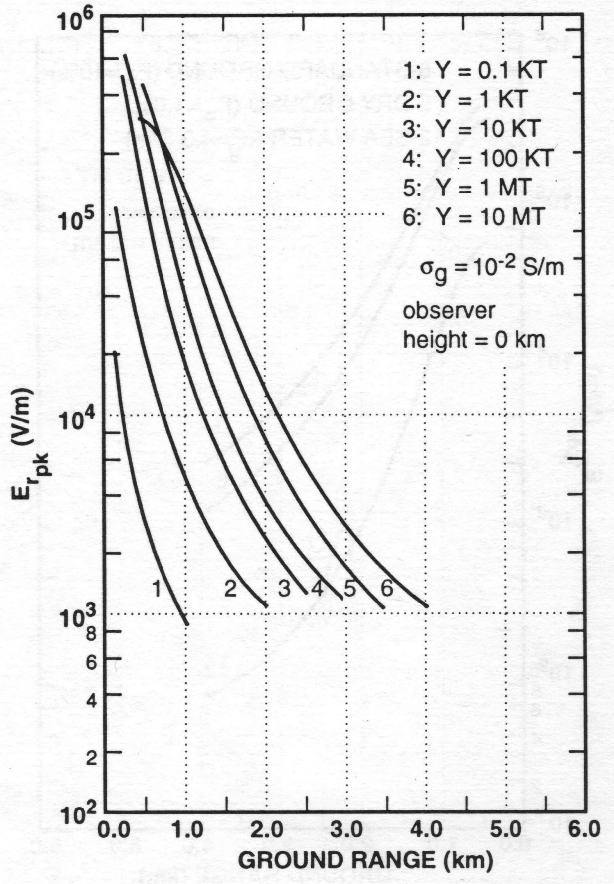


Figure 10.14. Variation of Peak Radial Electric Fields with Range from a Surface Burst for Various Total Yields.

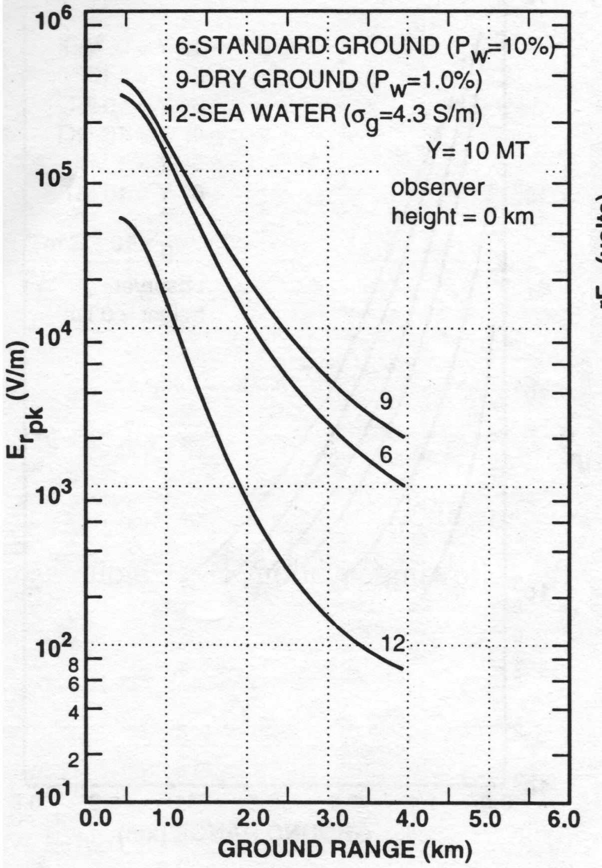


Figure 10.17. Variation of Peak Radial Electric Fields with Range from a Surface Burst for Different Ground Characteristics.

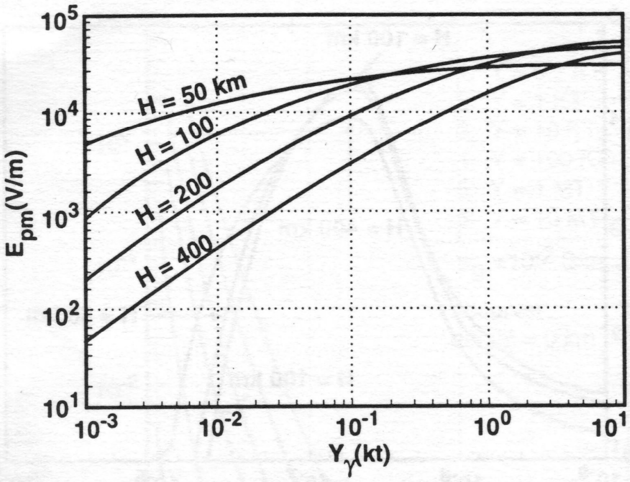


Figure 10.4. Maximum Estimated Peak Electric Field Versus Gamma Yield for Various Heights of Burst.

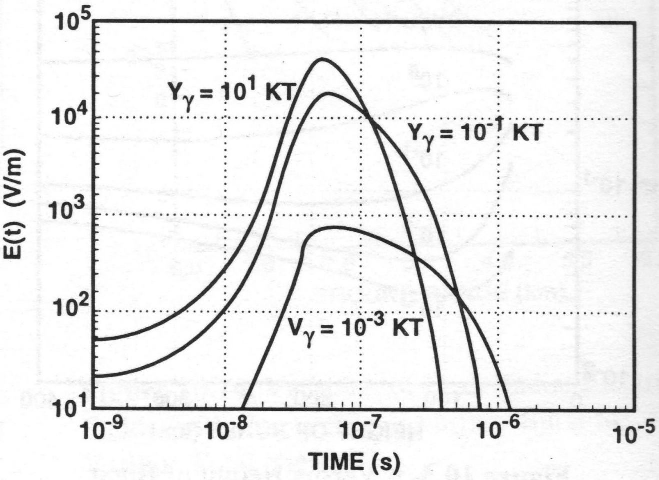


Figure 10.7. Electric Field Versus Time for Various Gamma Yields at 100 km

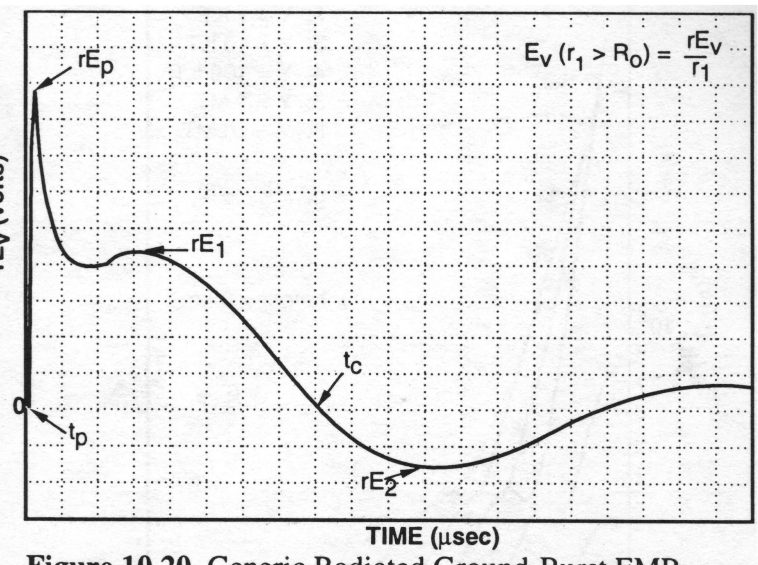
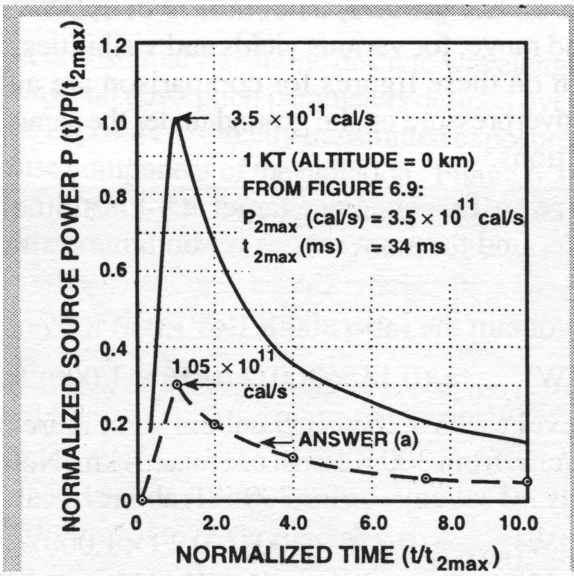
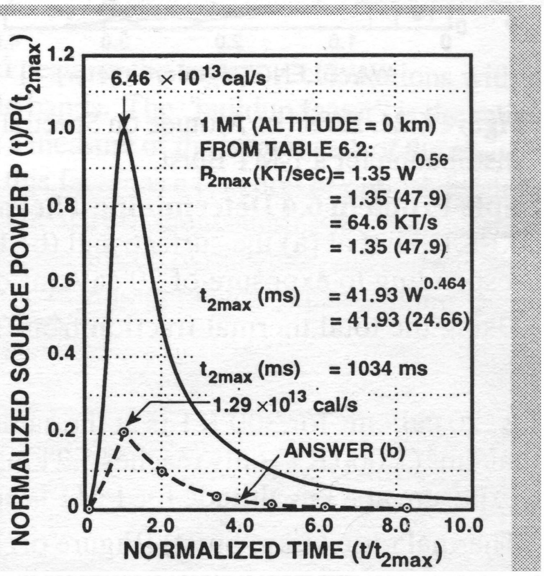


Figure 10.20. Generic Radiated Ground-Burst EMP Waveform.

Table 6.1. Thermal Fraction Values for Near-Surface Bursts.

	RECIPE			RADFLO	
Yield (KT)	Surface Burst Thermal Fraction	Nonsurface Burst Thermal Fraction	Transition Height (meters)	Surface Burst Thermal Fraction	Nonsurface Burst Thermal Fraction
1	0.045	0.35	4	.149	.350
10	0.066	0.34	8.6	.157	.350
100	0.13	0.33	18.5	.166	.350
1,000	0.16	0.31	40	.176	.350
10,000	0.17	0.26	86	.186	.350





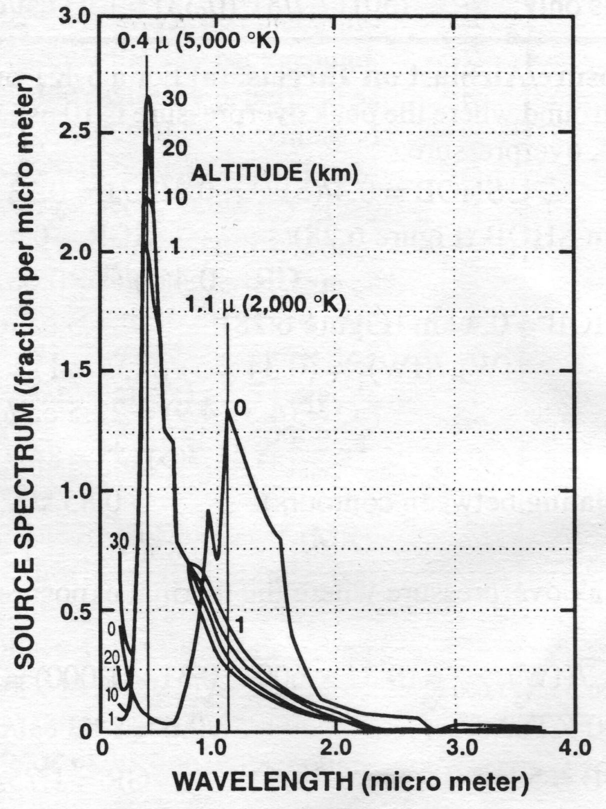


Figure 6.19. Effects of Altitude on Spectral Distribution for a 1-KT Burst.

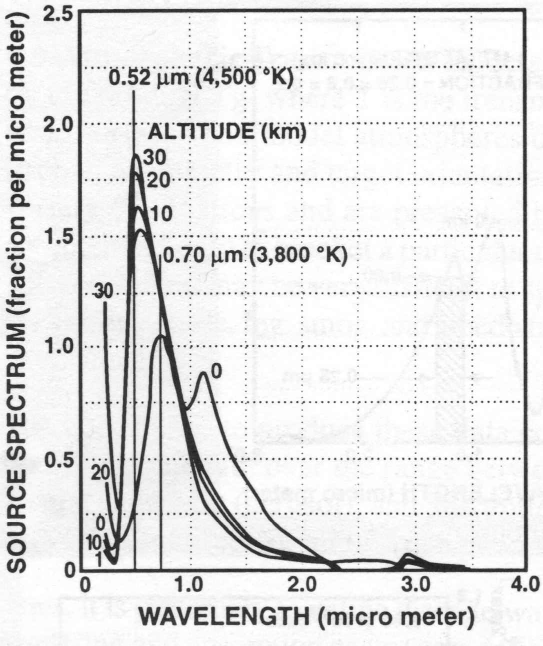


Figure 6.21. Effect of Altitude on Spectral Distribution for a 1-MT Burst.

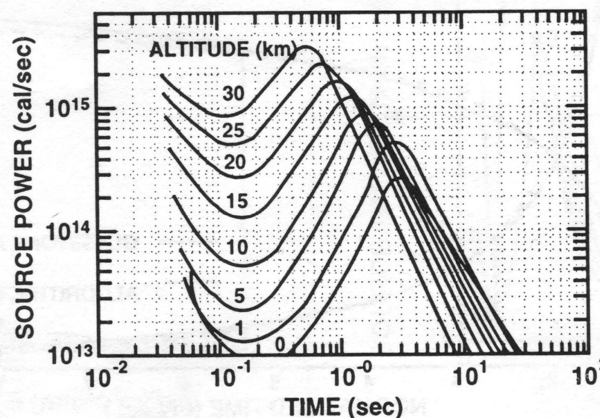


Figure 6.13. Effects of Altitude on Thermal Power for a 10-MT Burst.

6.3 Atmospheric Transmission Effects. As introduced in Equation 6.1, transmission effects are given by the product Tg, where T is the transmittance factor for a generalized geometry with idealized albedo surfaces and model atmospheres depending on the visibility. The geometry factor g includes fireball asymmetry and target orientation effects. Values of T and g have been computed for a wide variety of situations and are presented in graphical form for predictive purposes. Such predictions are intended only to bracket a particular case for which actual transmission factors will vary with time and space, and may be very difficult to specify quantitatively. In addition, the normal variables of humidity, dust, haze, fog, smog, and albedo factors will be even less predictable in rapidly changing wartime environments.

The codes used to produce these data compute both the direct and scattered components as a function of wavelength over the range between 0.3 and 4.0 μm. Scattering includes both Rayleigh (molecular) and Mie (aerosol), and absorption is calculated for water vapor, carbon dioxide, and ozone. The cross sections for all of these processes are wavelength dependent.

Thus, it is customary to define discrete wavelength bands and perform the transport calculations with the scattering and absorption parameters defined over the separate bands. The "buildup factor" is the ratio of the total exposure to directly transmitted exposure, and thus is a measure of the importance of the scattered or diffuse component of the radiation. Figure 6.38 illustrates this factor as a function of optical depth (integral of the product of the scattering cross section and number density of the scattering medium along the path from source to detector) for Pacific Test Site conditions and the albedo of seawater, and shows that the diffuse component may be much larger than the direct component at long ranges. The resulting angular distribution for one wavelength (0.55 μm) is shown in Figure 6.39.

6.3.1 Effects of Meteorological Conditions. This section considers the effects of aerosols and molecular absorption. Albedo effects will be discussed in Section 6.3.2.

6.3.1.1 Visibility. Daylight visibility is the distance at which a large dark object is just recognizable against the sky background. Nighttime visibility is defined as the longest distance at which an unfocused light of moderate intensity can be seen. Table 6.3 gives the international visibility code, relating a qualitative description of the atmosphere to observed visibilities. It is usually assumed that the transmittance is 5.5 percent along the distance corresponding to the visibility.

The "meteorological range" (MR) is the horizontal distance for which the transmittance of the atmosphere for a direct beam of light is 2 percent. The meteorological range is related to the atmospheric extinction cross section by:

$$\sigma_T = 3.91/MR \qquad (6.8)$$

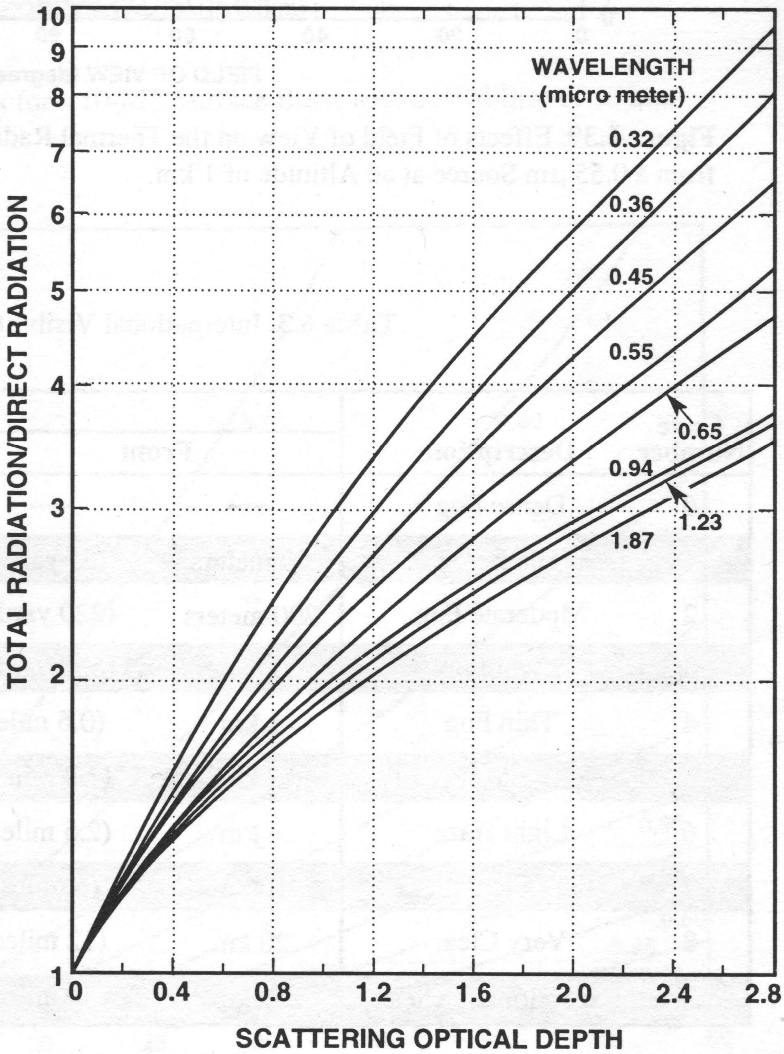


Figure 6.38. Comparison of Buildup Factors for Various Radiation Wavelengths Simulating Pacific Atmosphere with Both Source and Sampling at 1-km Altitude.

The relationship between the visibility and the meteorological range is:

$$V = 0.74\ MR\ . \tag{6.9}$$

In this section, all transmission predictions will be related to the visibility, and not to the meteorological range.

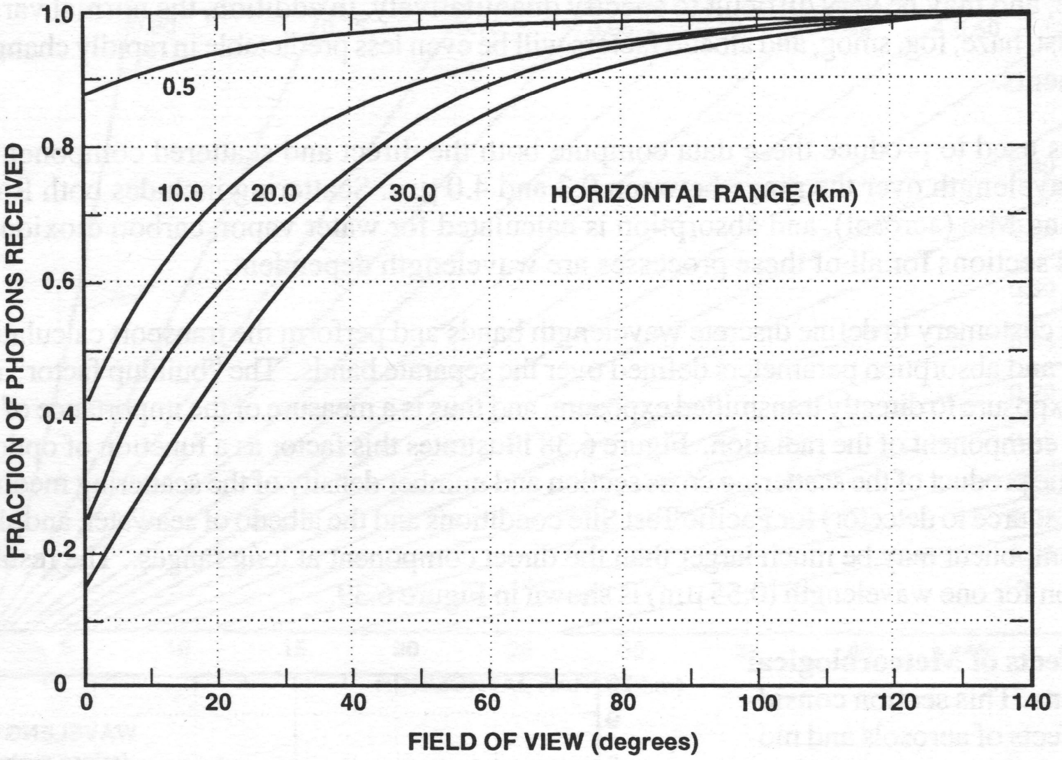


Figure 6.39. Effects of Field of View on the Thermal Radiation for a Target on the Ground from a 0.55 μm Source at an Altitude of 1 km.

Table 6.3. International Visibility Code.

Code Number	Description	Visibility From		To	
0	Dense Fog	—	—	50 meters	(55 yards)
1	Thick Fog	50 meters	(55 yards)	200 meters	(220 yards)
2	Moderate Fog	200 meters	(220 yards)	500 meters	(550 yards)
3	Light Fog	500 meters	(550 yards)	1 km	(0.6 mile)
4	Thin Fog	1 km	(0.6 mile)	2 km	(1.2 miles)
5	Haze	2 km	(1.2 miles)	4 km	(2.5 miles)
6	Light Haze	4 km	(2.5 miles)	10 km	(6 miles)
7	Clear	10 km	(6 miles)	20 km	(12 miles)
8	Very Clear	20 km	(12 miles)	50 km	(30 miles)
9	Exceptionally Clear	50 km	(30 miles)	—	—

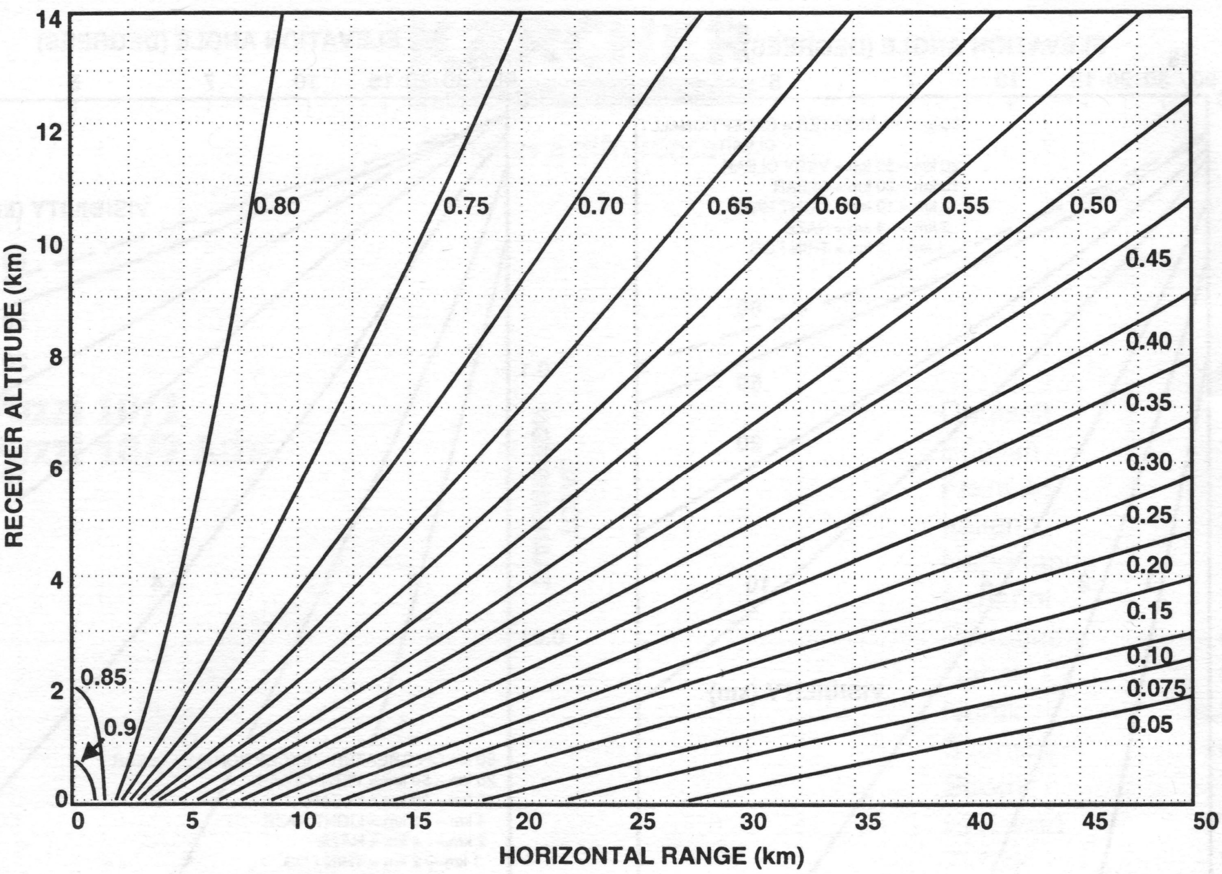


Figure 6.46. Transmission Contours for a 10-MT Surface Burst with a Visibility of 10 km.

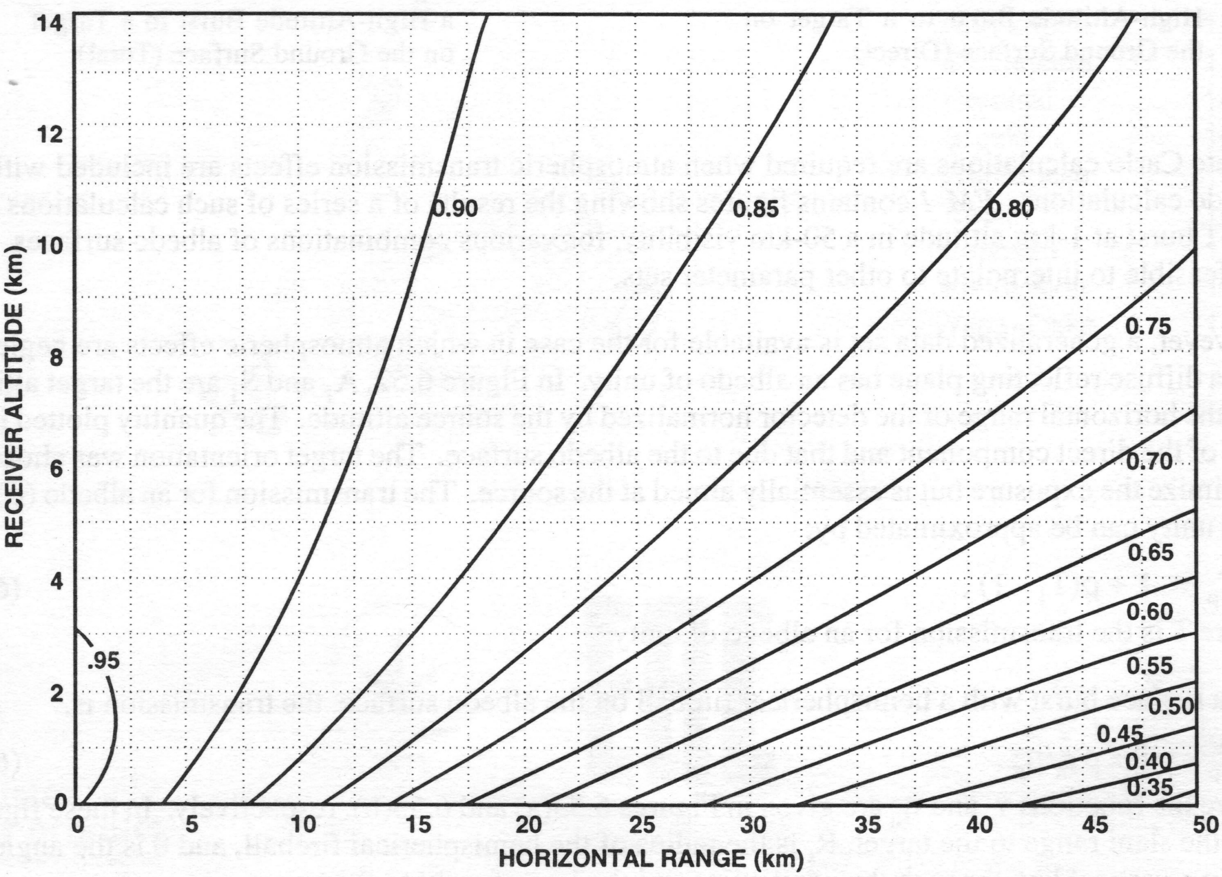


Figure 6.47. Transmission Contours for a 1-MT Burst at an Altitude of 1 km with a Visibility of 50 km.

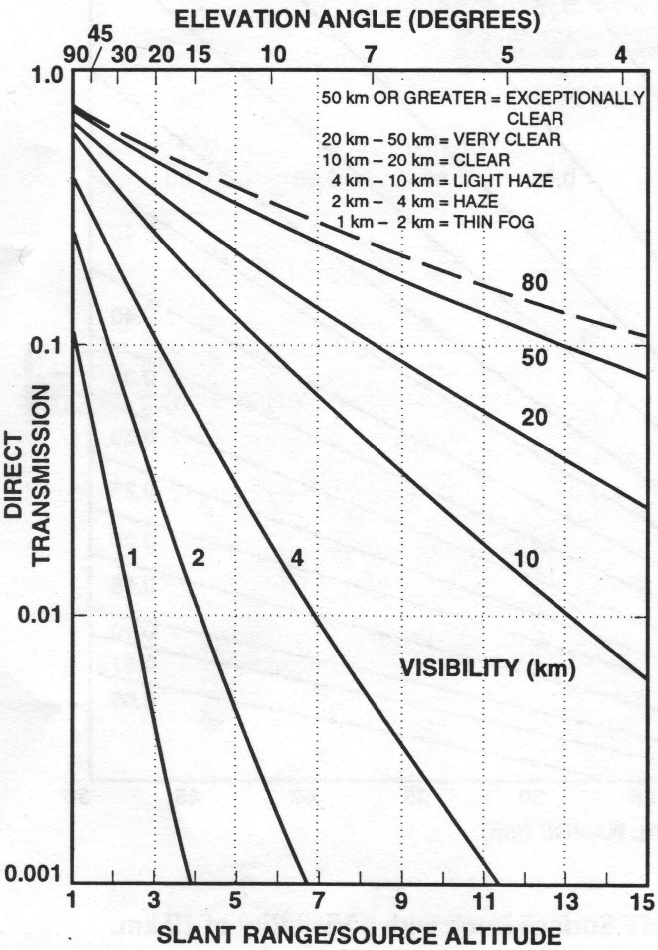


Figure 6.48(a). Transmission from a High-Altitude Burst to a Target on the Ground Surface (Direct).

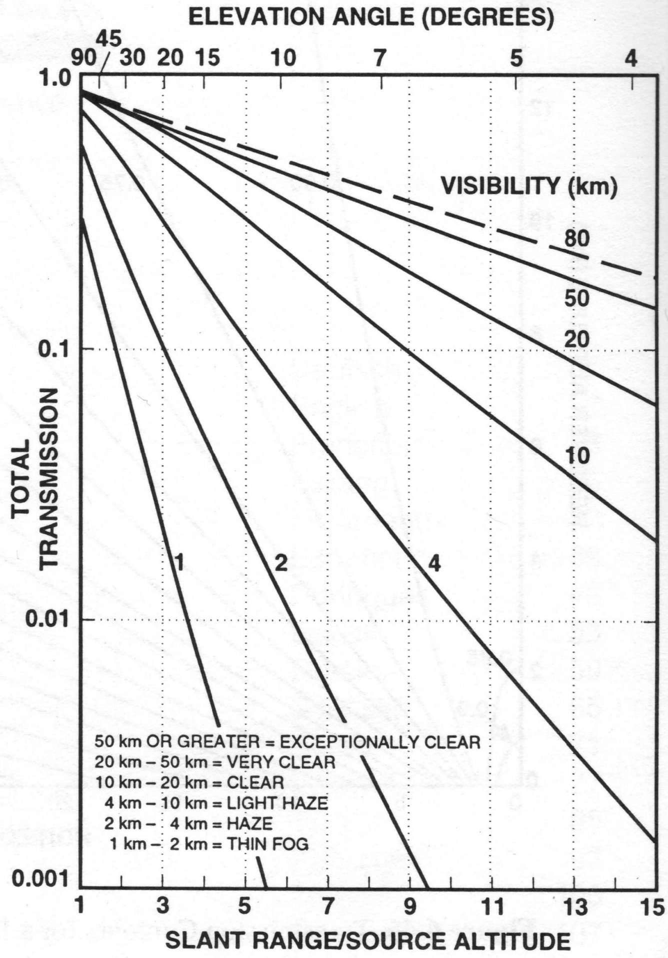


Figure 6.48(b). Transmission from a High-Altitude Burst to a Target on the Ground Surface (Total).

Monte Carlo calculations are required when atmospheric transmission effects are included with the albedo calculations. *EM-1* contains figures showing the results of a series of such calculations for a 1-MT burst at 1-km altitude in a 50-km visibility, for various combinations of albedo surfaces. It is not feasible to interpolate to other parameter sets.

However, a generalized data set is available for the case in which atmospheric effects are neglected and a diffuse reflecting plane has an albedo of unity. In Figure 6.52, A_1 and S_1 are the target altitude and the horizontal range of the detector normalized by the source altitude. The quantity plotted is the sum of the direct component and that due to the albedo surface. The target orientation was chosen to maximize the exposure but is essentially aimed at the source. The transmission for an albedo (ρ) less than unity can be approximated by:

$$T_\rho = 1 + \rho(T_1 - 1)\,, \tag{6.12}$$

where T is the transmission for an albedo of unity.

For a surface burst with a hemispherical fireball on the albedo surface, the transmission is,

$$T_\rho = 1 + \rho\gamma_n/\eta_n\,. \tag{6.13}$$

where the functions γ_n and η_n are given in Figures 6.53(a) and 6.53(b), respectively. In these figures, R is the slant range to the target, R_s is the radius of the hemispherical fireball, and θ is the angle between a vertical line through the burst point and the line of sight to the target.

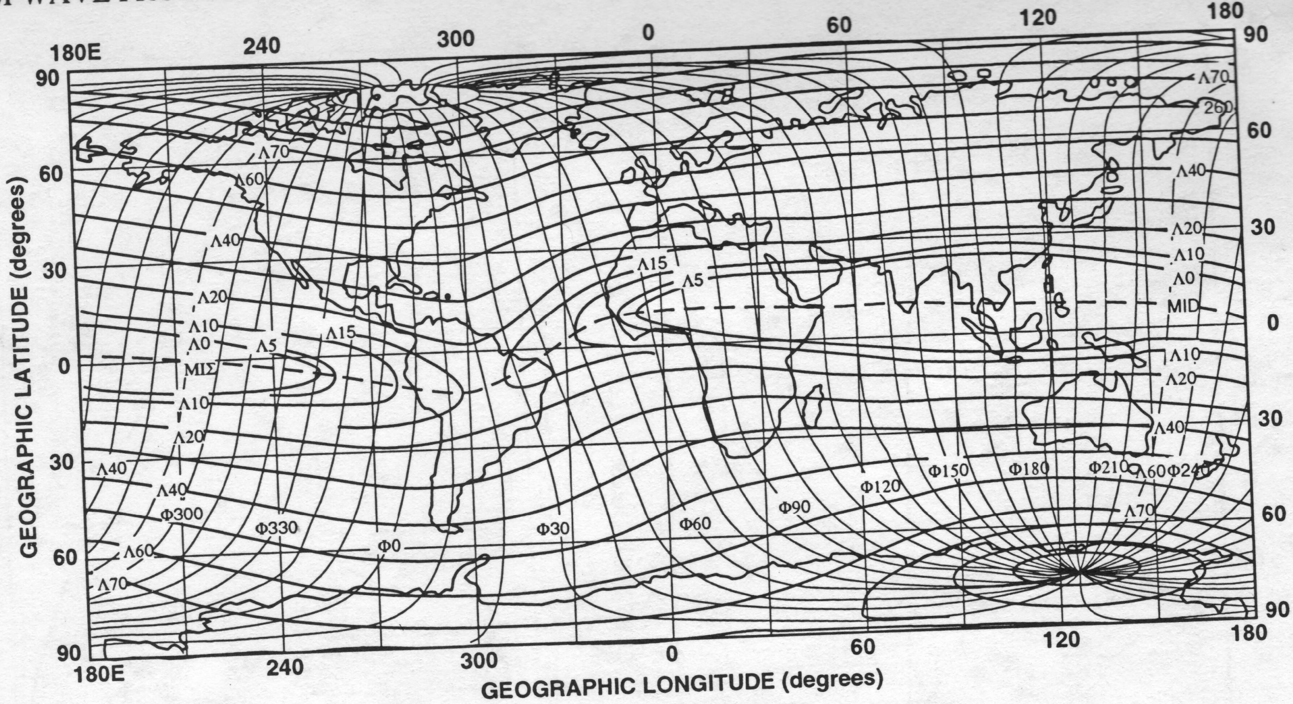


Figure 9.3. World Map of Geomagnetic Coordinates at 0 km Altitude.

emitted promptly (within a microsecond); about 5 to 10 percent is delayed radiation (gamma rays and beta particles) from decay of fission debris.

"Stopping altitudes" for the principal radiations from a nuclear weapon are shown in Table 9.1. These are the altitudes for radiation entering the atmosphere from above the altitude where mass penetrated equals the reciprocal of mass absorption coefficient. For detonations below the stopping altitude of a particular radiation, most of that radiation will be contained locally. When detonations occur above the stopping altitude of a particular radiation, that radiation can spread over large distances before being deposited and causing ionization. About 3×10^4 ion pairs are produced for each MeV of energy deposited in the atmosphere. About 3×10^{28} MeV are released per megaton of weapon yield.

9.1.2.1 Electron Density Within the Fireball. At altitudes below about 80 km, fireballs can be considered approximately homogeneous, with electron densities depending on burst altitude, yield, and time after burst. For detonations above about 100 km, electron densities vary greatly over the region of the fireball and the earth's magnetic field strongly influences debris motion and thus fireball shape. Figure 9.4 shows electron densities for a nominal 1 MT burst at four altitudes as a function of time, with accompanying sketches of fireball rise and expansion. For the 250 km burst, the density shown is the maximum, near the bottom of the rather non-homogeneous and dispersed fireball.

Figure 9.5 shows contours of mean electron density for a 1-MT burst at 250 km. The contours are shown on the meridian plane of a magnetic dipole coordinate system. The dipole coordinates α and β are related to magnetic spherical coordinates by:

$$\cos\alpha = (R_e/R)^2 \cos\theta\,, \tag{9.3}$$

$$\sin\beta = (R_e/R)^{1/2} \sin\theta\,, \tag{9.4}$$

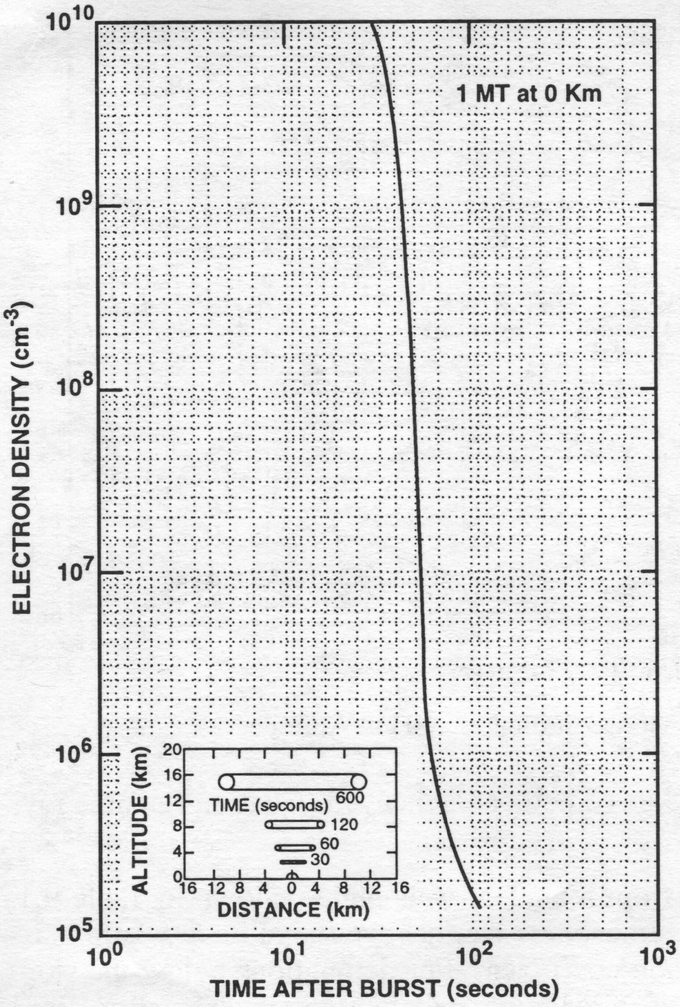
where θ = geomagnetic colatitude, and R_e = earth's radius.

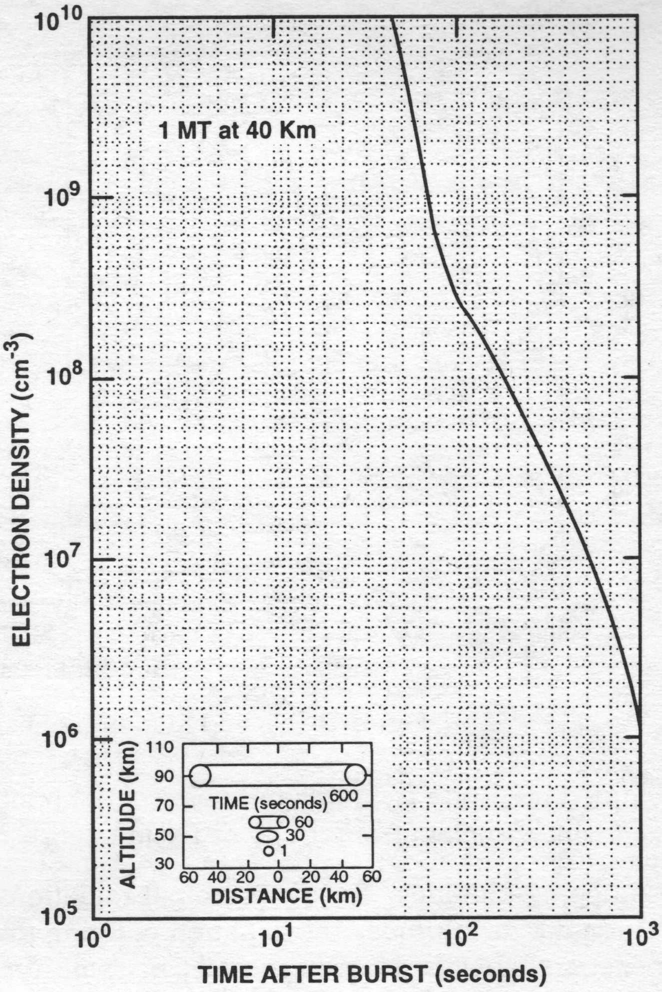
Lines of constant β are dipole field lines and lines of constant α are orthogonal to the field lines. The β-coordinate is related to the geomagnetic shell parameter L by:

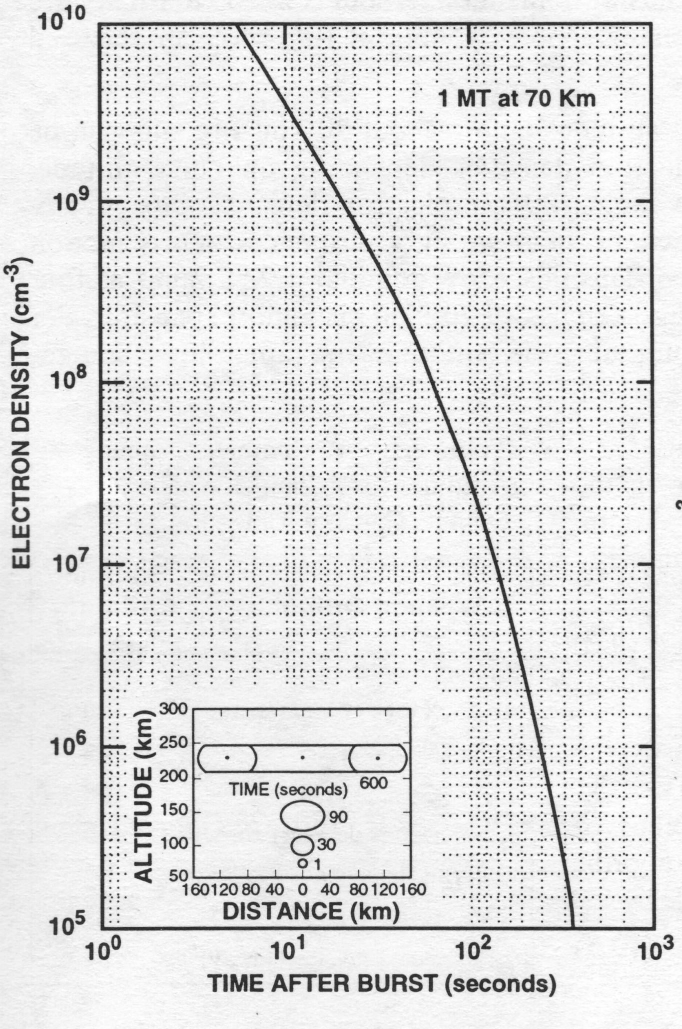
$$\beta = \sin^{-1}(L^{1/2})\,, \tag{9.5}$$

Table 9.1. Approximate Stopping Altitudes for Principal Weapon Outputs Causing Ionization.

Weapon Output	Stopping Altitude (km)
Prompt Radiation	
X rays (1-keV radiator)	80
Neutrons	25
Gamma rays	25
Debris (kinetic energy)	115
Delayed Radiation	
Gamma rays	25
Beta particles (1 MeV)	60







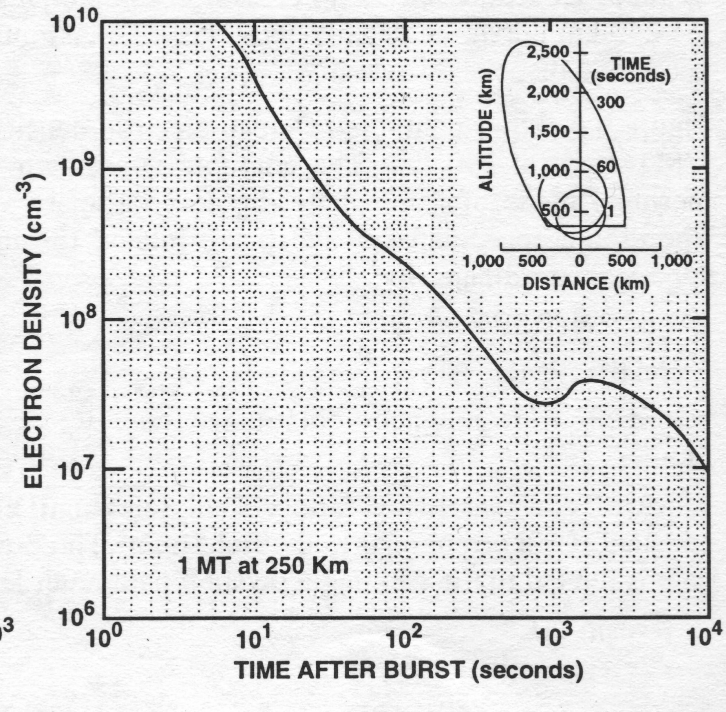
Figures arranged clockwise starting upper left:

Figure 9.4a. Fireball Electron Density, 1 MT at 0 km.

Figure 9.4b. Fireball Electron Density, 1 MT at 40 km.

Figure 9.4c. Fireball Electron Density, 1 MT at 70 km.

Figure 9.4d. Fireball Electron Density at a Point Near the Bottom of the Fireball, 1 MT at 250 km.



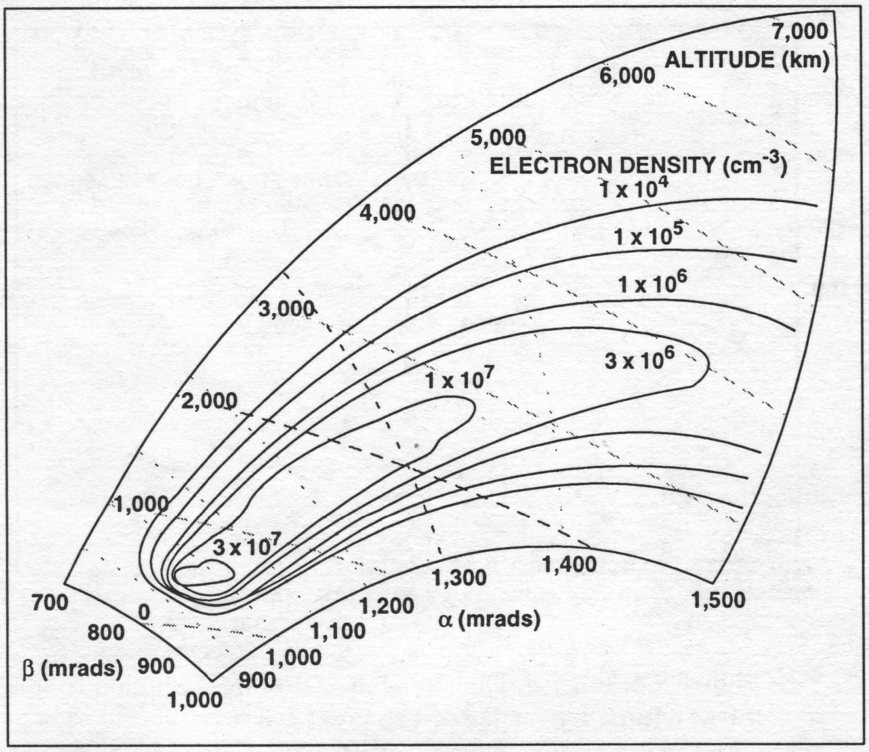


Figure 9.5. Electron Density Contours in Magnetic Meridian Plane, 1 MT at 250 km, t = 1,000 seconds.

where $L = R_o/R_e$ and

R_o = distance from the field line at the magnetic equator to the center of the earth.

9.1.2.2 Electron Density Outside the Fireball Caused by Prompt Radiation. For bursts below 25 km, prompt radiation outside the fireball is insignificant. Between 25 and 80 km altitude, neutrons produce ionization over several hundred km, but the gamma ray contribution is insignificant. Above 80 km, x rays cause widespread ionization and debris kinetic energy contributes for bursts above about 115 km.

Figure 9.6 shows the initial ionization caused by prompt radiation from a nominal megaton weapon detonated at 120 km. Below about 100 km, the electron and ion density after 1 second will be essentially independent of the initial ionization if it is greater than 10^7 ion pairs/cm^3, termed "saturation." Figure 9.7 shows the altitude dependence of the electron density for several times after a saturation impulse. The inset illustrates the horizontal extent of the region that can be saturated by prompt radiation as a function of detonation altitude.

Figure 9.8 shows the initial fireball region and the E- and F-region ionization outside the fireball caused by prompt radiation for a 1-MT burst at 250 km. The fireball is produced by the deposition of debris kinetic energy in the atmosphere. Some of the debris kinetic energy can escape the fireball as ultraviolet radiation produced as the fireball is formed, and some as heavy-particle kinetic energy. The x-ray and ultraviolet ionization regions are symmetrical about the burst point, while the heavy-particle ionization is confined by the geomagnetic field and is more localized and more highly ionized.

Prompt energy deposition above about 90 km can heat as well as ionize the air, causing atmospheric heave. The prompt ionization regions outside the fireball above 100 km can become striated, with onset times of tens of minutes. Neutron decay (half-life 12 minutes) beta particles can produce weak, but observable, ionization at the geomagnetic conjugate point.

9.1.2.3 Electron Density Outside the Fireball Caused by Delayed Radiation. Delayed gamma rays and beta particles from fission debris produce ionization characterized by a production rate of ion pairs per unit volume per unit time. For detonation below several hundred kilometers, the fission debris is initially within the fireball and is carried upward and expands with the fireball.

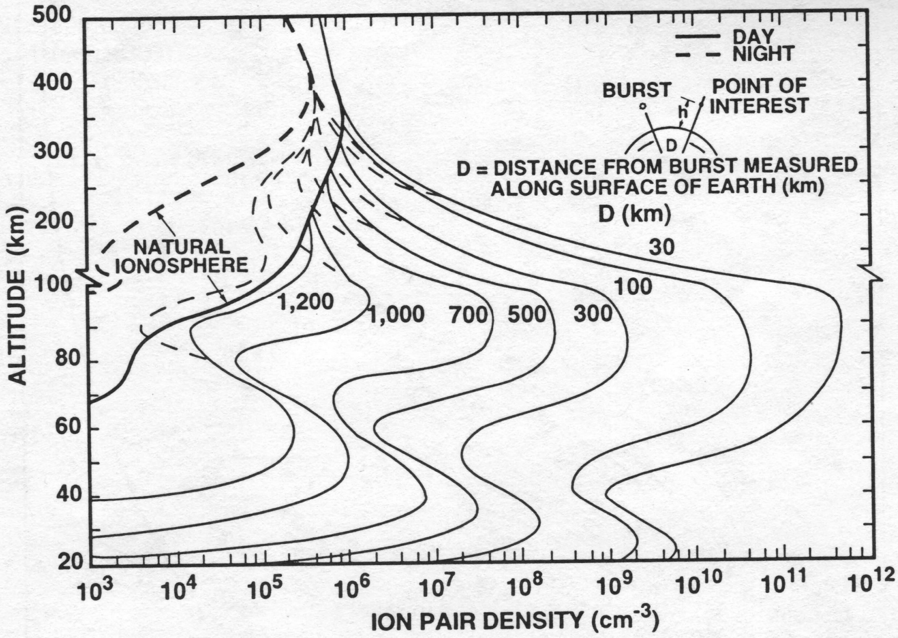


Figure 9.6. Ion-Pair Density Due to Prompt Radiation from a 1-MT Burst Detonated at 120 km, t = 0.

Gamma Rays. Debris gammas emitted below their stopping altitude (25 km) form a local ionization region around the fireball that can affect fireball thermal emission and EM energy scattering. Above this altitude, most gamma-ray energy is deposited near the stopping altitude, but maximum electron density usually occurs at higher altitudes where the electron lifetimes are longer. Figure 9.9 shows electron density contours for debris at 30 km, in which the persistence of ionization at the altitude of the D-region is evident.

When the fission debris and the point of interest are both well above the gamma-ray stopping altitude, the ion-pair production rate and electron and ion densities caused by gamma rays can be expressed conveniently in terms of a radiation intensity parameter I_γ, defined by:

$$I_\gamma = (3.2 \times 10^6\, W_F/R^2(1 + t)^{1.2})\ \mathrm{W/m^2}\ , \qquad (9.6)$$

where W_F = fission yield (MT)

R = radial distance from debris center to point of interest (km)

t = time after detonation (seconds).

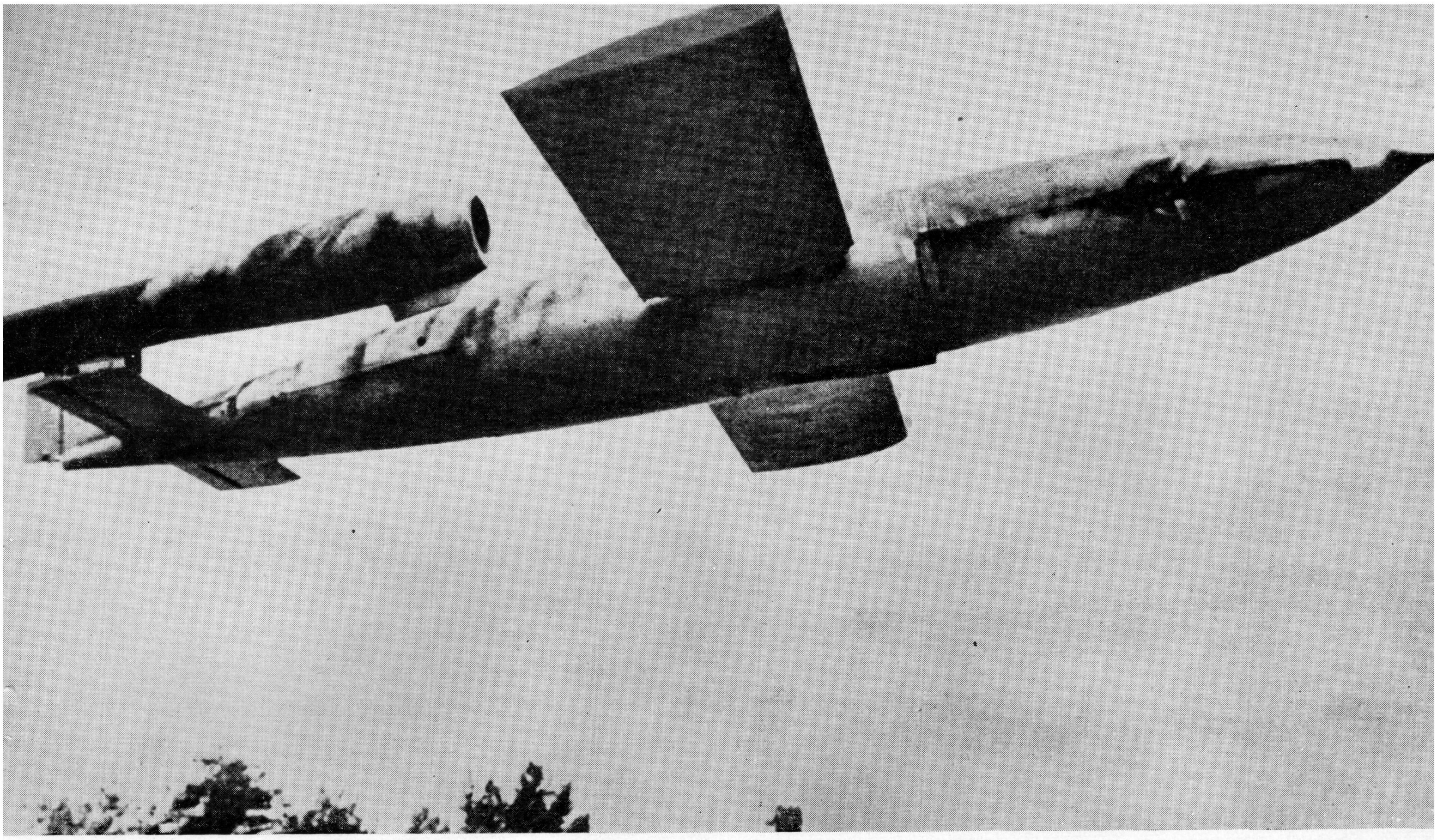
Figure 9.10 shows quasi-equilibrium electron densities for particular values of I_γ. They are the values that would be reached if the production rate remained constant and if sufficient time were allowed for equilibrium conditions to be reached. The inset in Figure 9.10 illustrates the horizontal extent as a function of debris altitude for which the electron densities are applicable.

Beta Particles. Below the beta-particle stopping altitude, beta particles form an electron-ion sheath around the debris region which will have similar optical absorption effects and EM-wave scattering as described for gamma-rays. When debris occurs at higher altitudes, significantly above the beta stopping altitude, beta particles will follow EM field lines and create ionization, both below the debris and at the conjugate point, at the beta stopping altitude. Each of these areas will be surrounded by a somewhat larger area of Compton electron ionization. The ion-pair production rate and electron density caused by beta particles can be expressed conveniently in terms of a radiation intensity parameter N_β defined by:

$$N_\beta = 8.8 \times 10^{15}\, W_F / [A(1 + t)^{1.2}]\ \mathrm{betas/cm^2\text{-}sec^{1.2}}\ , \qquad (9.7)$$

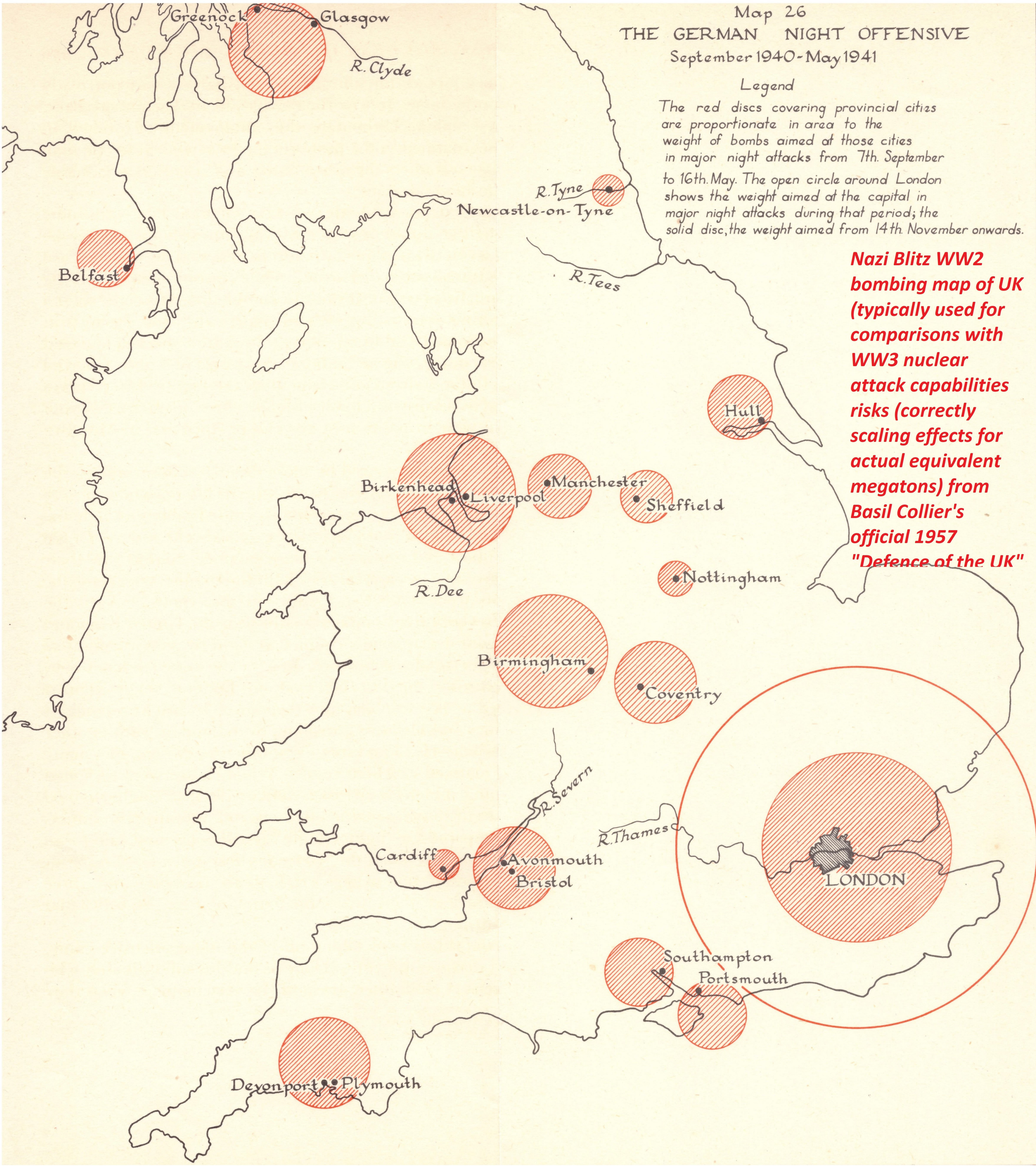
where A = area covered by fission debris in square kilometers.

Figure 9.11 shows the quasi-equilibrium electron density caused by beta particles for particular values of N_β. These curves apply if the fission debris is well above the beta stopping altitude and if the debris is uniformly distributed over the area A.



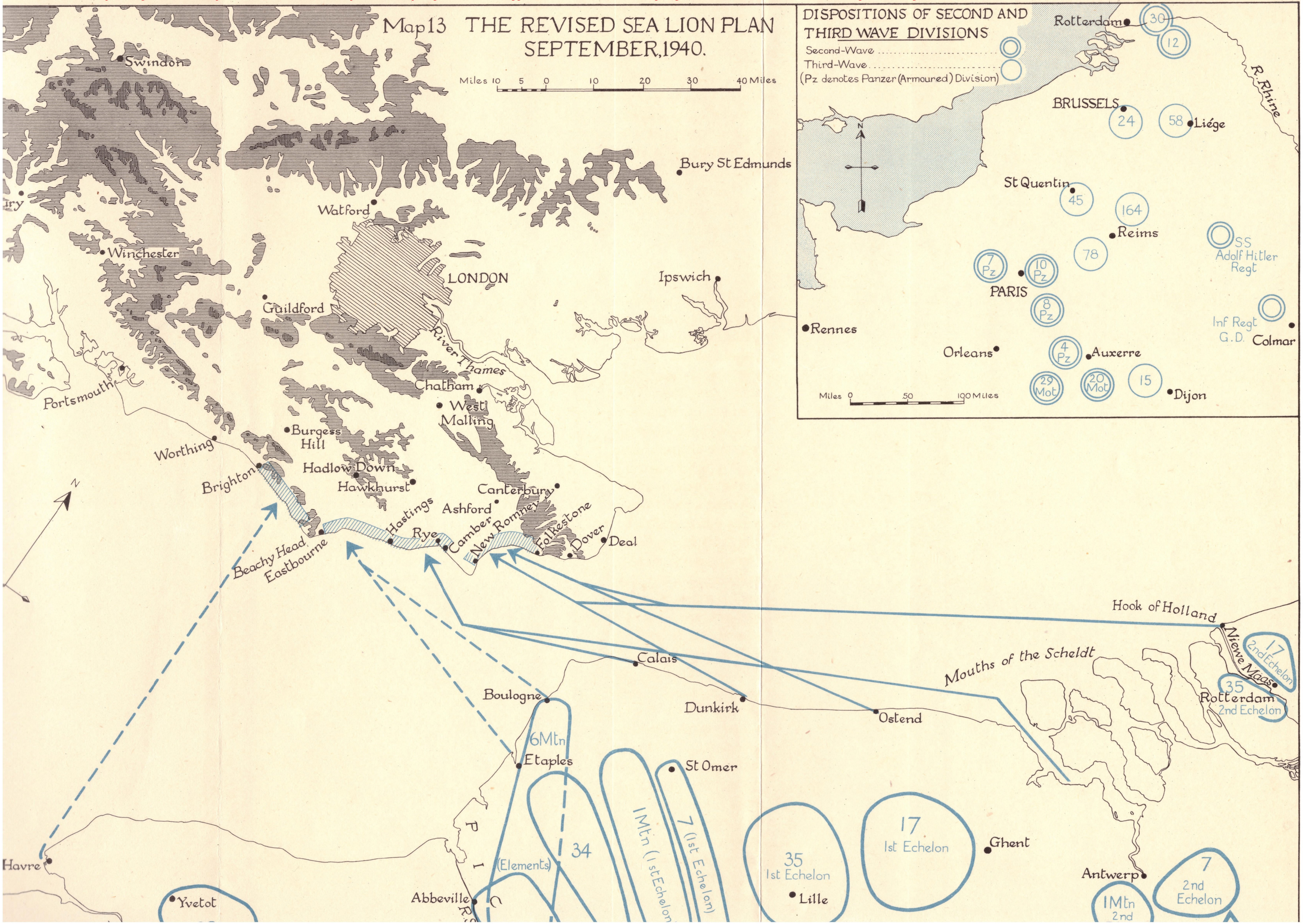
German Flying Bomb (*FZG.76*) immediately after Launching.

German Long-Range Rocket (*A-4*) in process of elevation to Firing Position.



Map 26
THE GERMAN NIGHT OFFENSIVE
September 1940 - May 1941
Legend
The red discs covering provincial cities are proportionate in area to the weight of bombs aimed at those cities in major night attacks from 7th. September to 16th. May. The open circle around London shows the weight aimed at the capital in major night attacks during that period; the solid disc, the weight aimed from 14th. November onwards.
Nazi Blitz WW2 bombing map of UK (typically used for comparisons with WW3 nuclear attack capabilities risks (correctly scaling effects for actual equivalent megatons) from Basil Collier's official 1957 "Defence of the UK"
Greenock
Glasgow
R. Clyde
R. Tyne
Newcastle-on-Tyne
Belfast
R. Tees
Hull
Birkenhead
Liverpool
Manchester
Sheffield
R. Dee
Nottingham
Birmingham
Coventry
R. Severn
R. Thames
Cardiff
Avonmouth
Bristol
LONDON
Southampton
Portsmouth
Devonport
Plymouth

Nazi invasion plan for UK - Operation Sea Lion plan map - from the official British history of WW2, Basil Collier's Defence of UK, 1957



14 april 42 Hitler order to bomb UK cities - Basil Collier's "Def. of UK"

APPENDIX XXXVI

The Führer's Order for the 'Baedeker' Offensive

WFST/Op(L) *FHQ. 14 April 1942*

Kr-Fernschreiben an

Ob. d. L./Lw. Fü. St. Ia Robinson

Betrifft: Luftkriegführung gegen die britischen Inseln

Der Führer hat geordnet, dass der Luftkrieg gegen England in erhöhtem Masse angriffsweise zu führen ist. Hierbei sollen solche Ziele im Vordergrund stehen, deren Bekämpfung möglichst empfindliche Rückwirkungen für das öffentliche Leben mit sich bringt. Neben der Bekämpfung von Hafen- und Industrieanlagen sind hierzu auch im Rahmen der Vergeltung Terrorangriffe gegen Städte ausser London durchzuführen. Verminungen sind zu Gunsten dieser Aufgaben einzuschränken.

OKW WFST Op
Nr. 55 672/42 Gkdos. Chefs.

(TRANSLATION)

Armed Forces Operations Staff/Ops (Air),
Führer Headquarters, 14 April 1942

Teletype message to: C.-in-C. G.A.F./Operations Staff Ia Robinson

Subject: Conduct of air warfare against the British Isles

The Führer has ordered that air warfare against England is to be given a more aggressive stamp. Accordingly when targets are being selected, preference is to be given to those where attacks are likely to have the greatest possible effect on civilian life. Besides raids on ports and industry, terror attacks of a retaliatory nature are to be carried out against towns other than London. Minelaying is to be scaled down in favour of these attacks.

Supreme Headquarters Armed Forces
Operations Staff/Ops
No. 55 672/42 Most Secret.

REFLECTIONS OF A NUCLEAR WEAPONEER

FRANK H. SHELTON

Frank H. Shelton

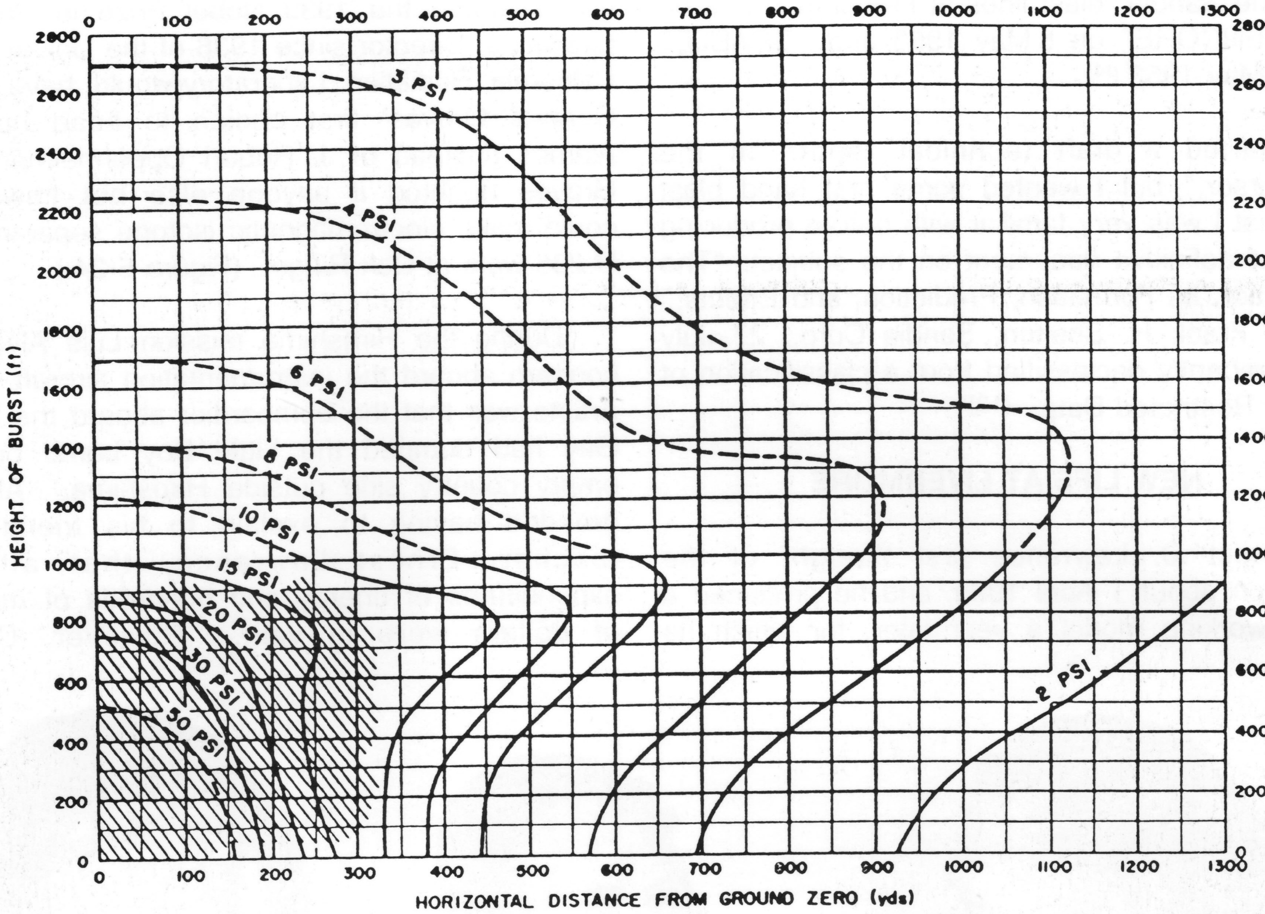


FIGURE 5-22. HEIGHT OF BURST CURVES (SCALED TO 1 KT AT SEA LEVEL)

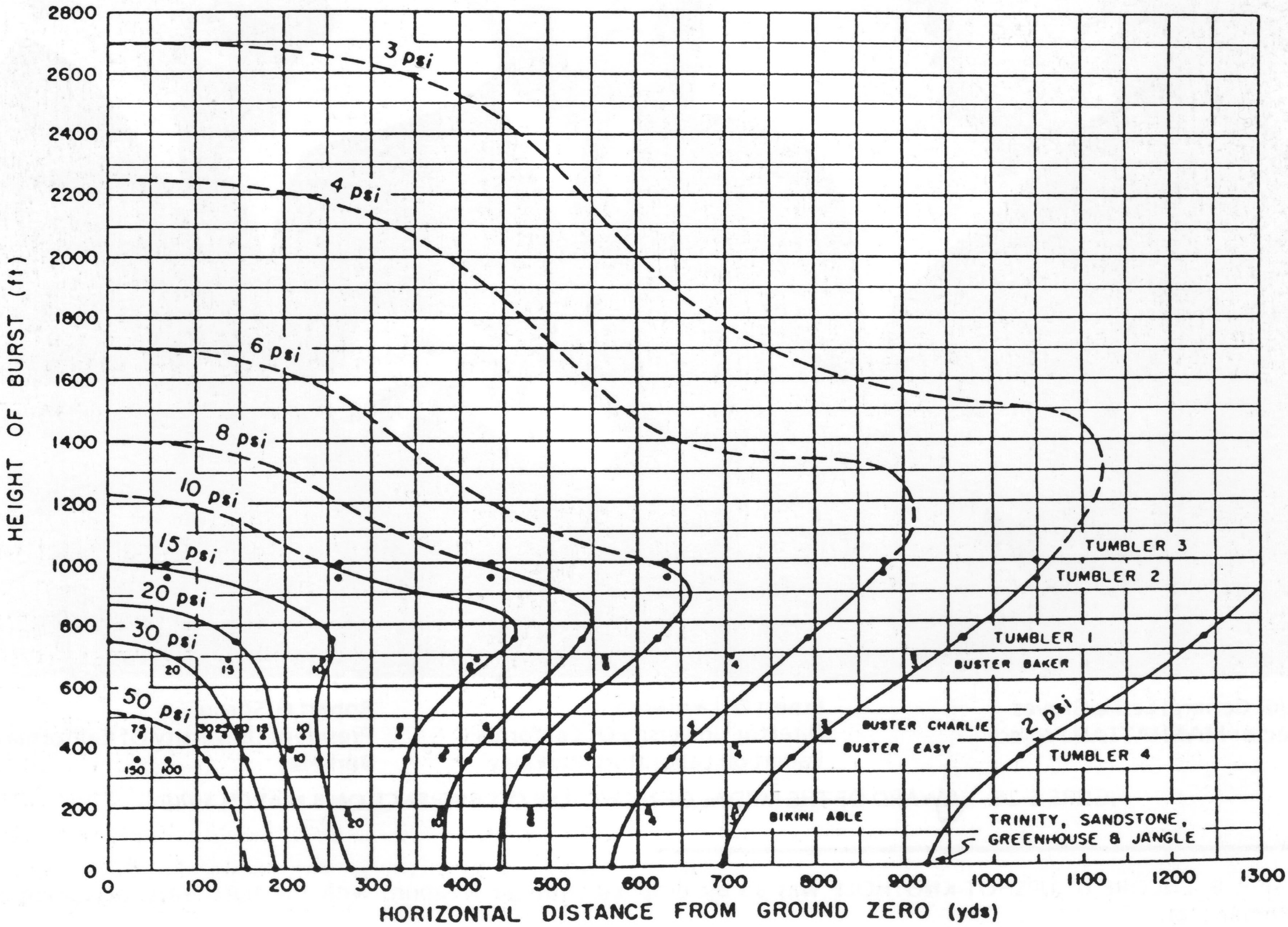


FIGURE 5-23 EMPIRICAL HEIGHT OF BURST CURVES FOR NUCLEAR WEAPONS

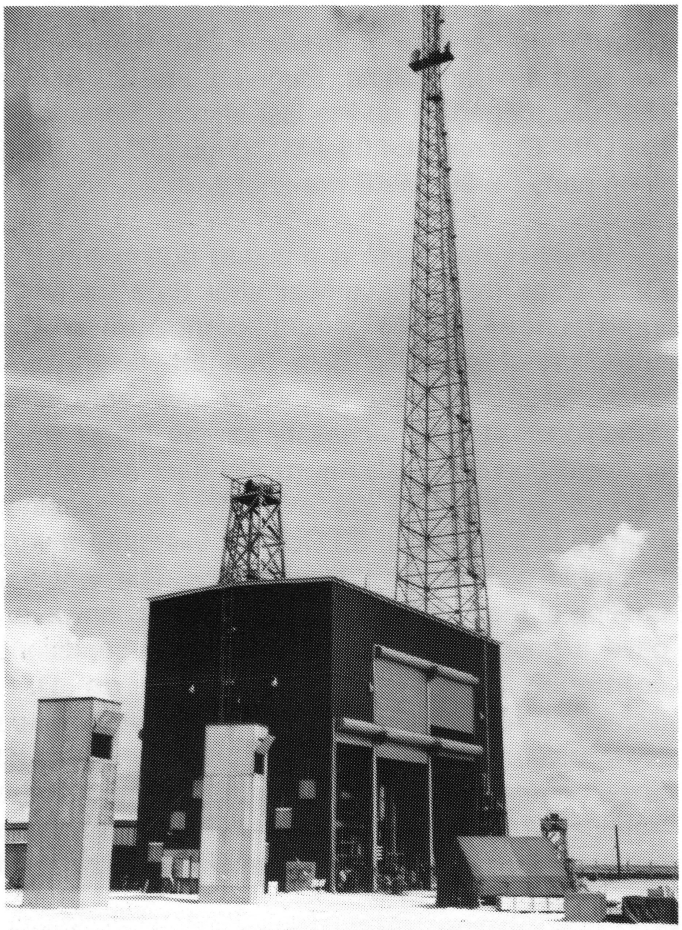


FIGURE 5-27. MIKE DEVICE CAB ON ELUGELAB ISLAND

Final Preparations For MIKE

Final assembly of the MIKE nuclear device occurred the afternoon of the day before the shot; this assembly was completed about an hour before general evacuation of Task Force 132 from Eniwetok Atoll was completed at 6:00 PM, at which time only the USS Curtiss and the USS Estes remained in the lagoon. Detonation of the MIKE thermonuclear device was scheduled for 0715 on 1 November 1952, Eniwetok time, which is on the west side of the International Date line (i.e., 31 October U.S. time). Sometime on 31 October, a P2V aircraft was sent to warn off a British merchant vessel, the SS Hartismere, that was sailing in the direction of Eniwetok and into the possible path of fallout from the shot. The P2V developed engine trouble and turned back. It made an emergency landing on the already evacuated Eniwetok landing strip at about 8:30 PM. The aircraft's crew was flown by heliocopter to the Rendova, waiting in the lagoon, after which the ship put to sea. About this time, six men normally assigned to the USS Estes could not be found but turned up on the USS Collins at about 10:30 PM. The British ship Hartismere was found by another P2V in the early hours of shot day and

FIGURE 5-28. KRAUSE-OGLE HELIUM BOX FROM MIKE CAB TO STATION 200

FIGURE 5-29. MIKE FIRING PARTY
H. E. Grier, S. W. Burriss, R. T. Lunger, M. D. Sprinkel

diverted to a safe course. The firing party departed the shot island, Elugelab, at 3:00 AM on shot day, departing on the last ship in the lagoon, the USS Curtiss, at 4:05 AM. (Figure 5-29, MIKE firing party.; 5-30, MIKE pre-shot.)

Weather had been a problem during most of October as the 1 November shot date for MIKE approached. Rain would compromise the collection of scientific data, but the winds aloft were the determining factor for favorable shot conditions. It was necessary for the fallout track to avoid populated islands to the east and south, as well as the task force itself. The weather briefing at 9:30 PM on 30 October indicated a very favorable picture for 1 November. The weather briefing at the same hour on 31 October, however, gave a poor outlook, and the weather conditions continued to deteriorate all day on D-1. Sometime around midnight the winds aloft shifted to a very favorable direction and speed at all upper levels, including the Krakatoes above the tropopause at 56,000 feet, making it possible to predict that the fallout track would be north and

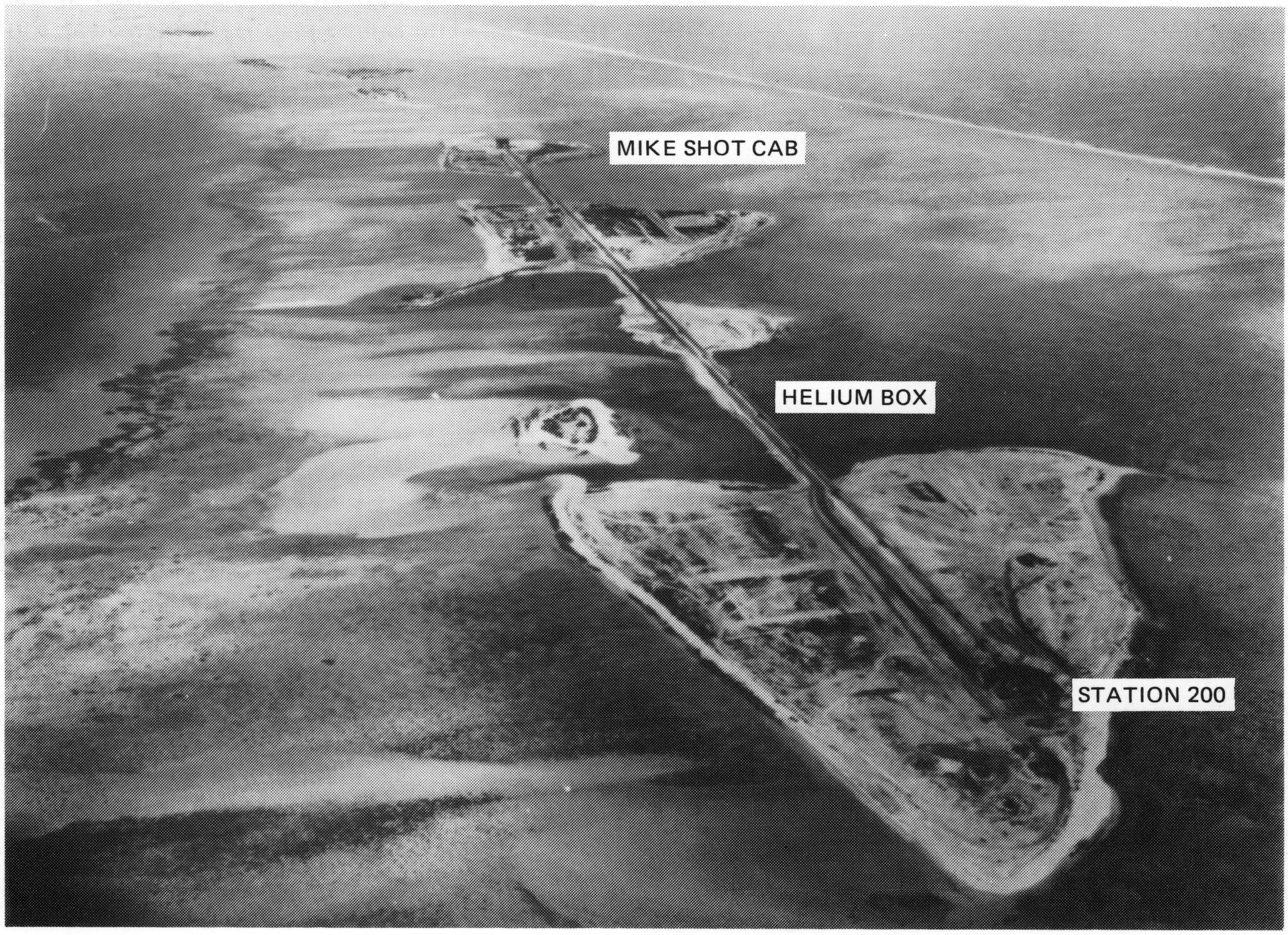
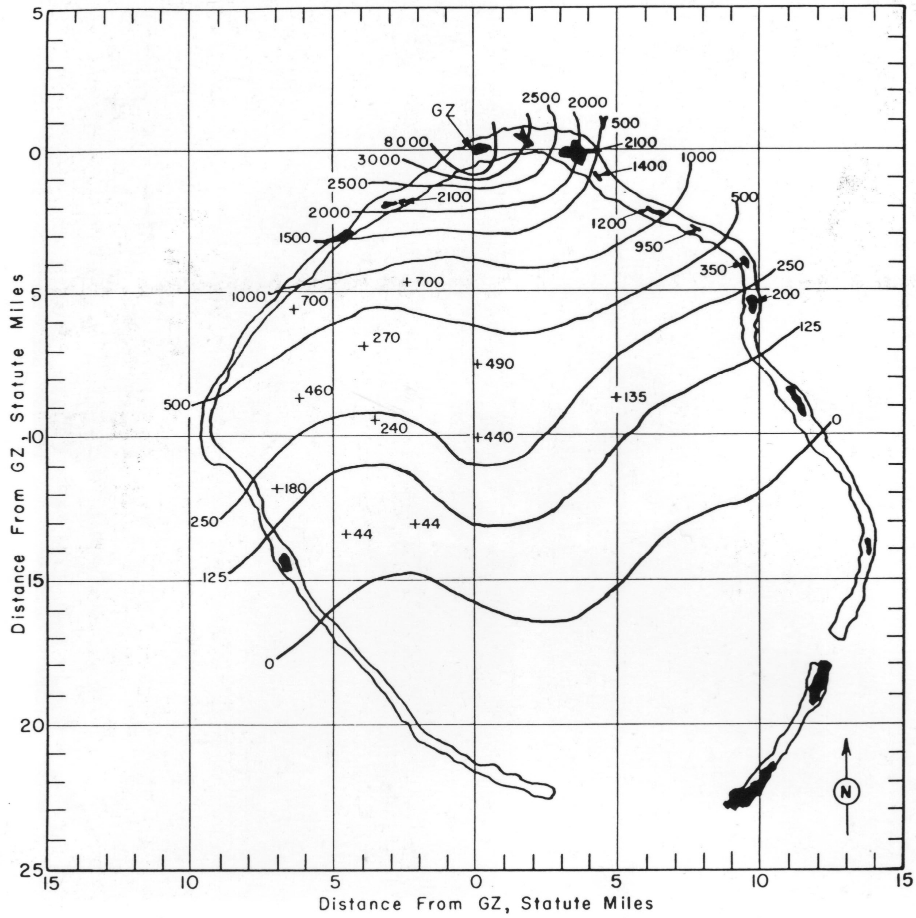


FIGURE 5-30. IVY MIKE SITE ON D-14 VIEWING NORTHWEST, HELIUM BOX EXPERIMENT FROM STATION 200 TO MIKE CAB

FIGURE 5-33. IVY MIKE D-1 (31 OCTOBER 1952) VIEWING NORTHWEST FROM STATION 200 TO SHOT CAB

FIGURE 5-34. IVY MIKE POST-SHOT D + 2 (3 NOVEMBER 1952)
VIEWING NORTHWEST FROM STATION 200, SHOT PRESSURE WAS 330 PSI



IVY MIKE - ATOLL DOSE RATES IN R/HR AT H + 1 HR

RUCHI ISLAND WAS 2.3 KM WEST OF GROUND ZERO AT ABOUT 3000 R/HR AT ONE HOUR

FIGURE 5-35. IVY MIKE POST-SHOT STATION 520 ON RUCHI ISLAND; JOHN MALIK ON REENTRY ON D + 4 (5 NOVEMBER 1952); DOSE RATE OF 3000 R/HR AT 1 HR HAD DECREASED TO ABOUT 12 R/HR. [30]

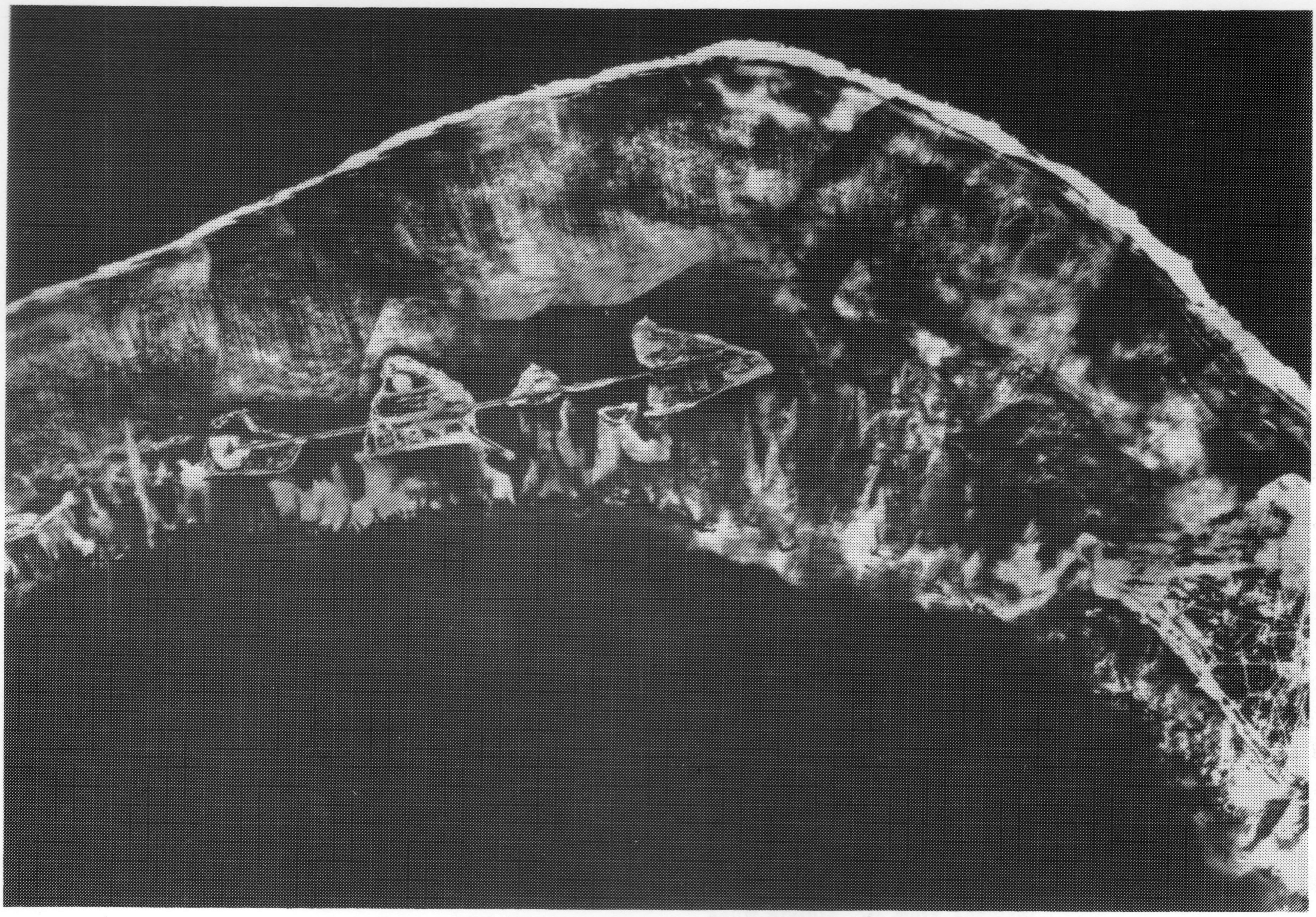


FIGURE 5-36. ENIWETOK ISLANDS PRE-SHOT ON D-9 (21 OCTOBER 1952)

FIGURE 5-37. ENIWETOK ISLANDS POST-SHOT ON D + 2 (3 NOVEMBER 1952)

the Pacific. Good news slowly trickled in. Fallout on the northern atoll island had delayed the recovery of blast records from the MIKE detonation. (Figure 5-38.) (21, 22, 23, 35)

KING Shot

KING was a stockpile weapon modified to produce a 500 kiloton (KT) development test of a fission design, that would provide the Air Force's Strategic Air Command (SAC) an interim alternative to a thermonuclear weapon capability. The weapon was transported by air to Kwajalein Island in the Pacific from Kirtland AFB on 4 November and was moved aboard the USS Curtiss to prepare it for the detonation. Curtiss had moved down from Eniwetok following MIKE shot and served as the workshop for the KING weapon at Kwajalein, much as it had for the MIKE weapon at Elugelab Island.

Thermal measurements were considered the most important of the KING shot effects programs. A clear atmospheric path from the burst point to the ground-based instruments on Runit Island was therefore a desirable shot criterion, especially below 2,000 feet. With the typical tropical meteorological conditions that existed at Eniwetok Atoll, this requirement caused several postponements of KING shot. (R)

Since preparations for KING shot were well advanced, and weather trends looked favorable, Commander Joint Task Force 132, Major General Clarkson, reported to the Department of the Army and the Atomic Energy Commission that the

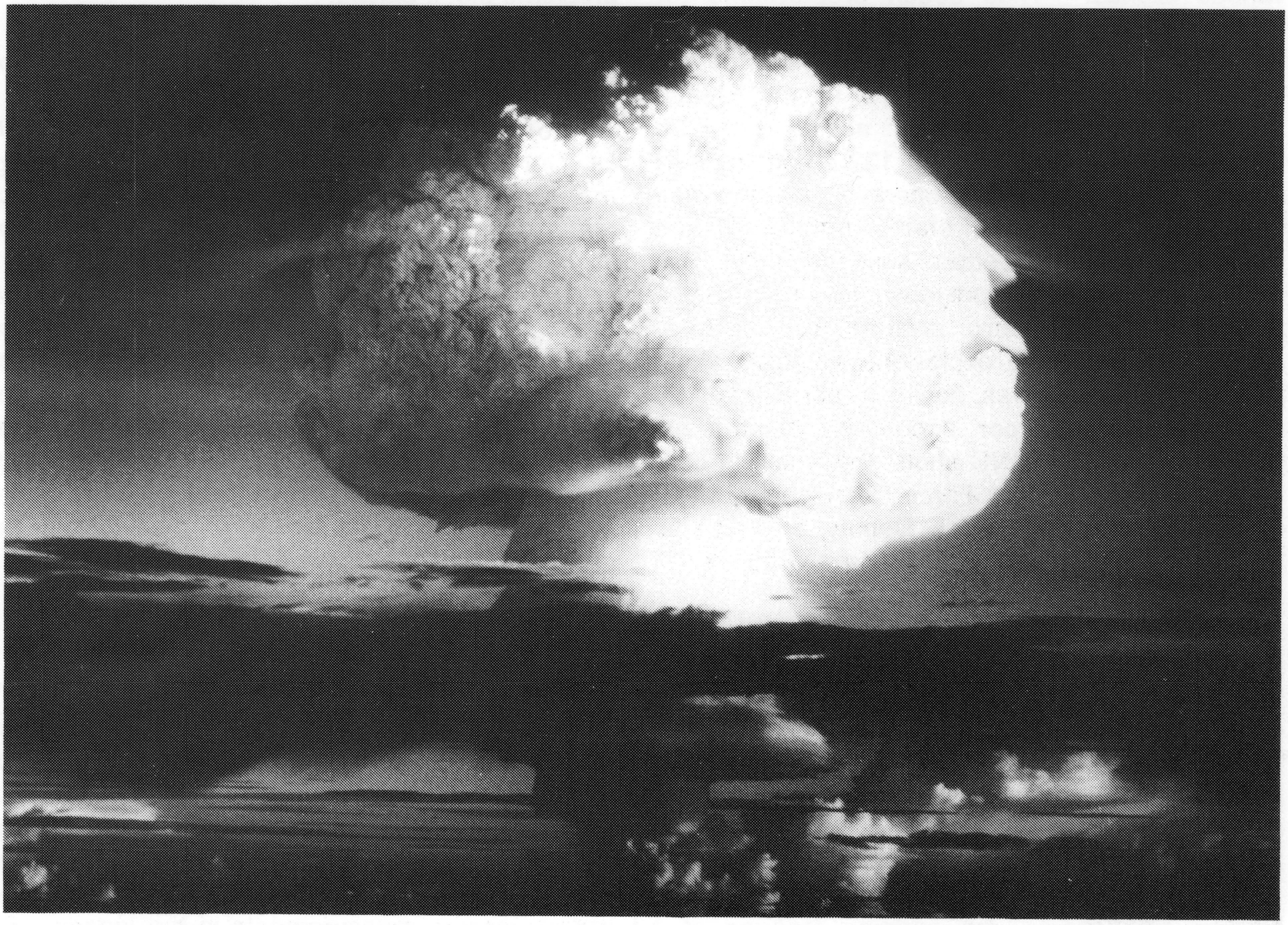


FIGURE 5-38. MIKE SHOT, 1 NOVEMBER 1952, 10.4 MEGATONS SURFACE BURST ON ELUGELAB ISLAND

(R) I wrote a document in September 1953, that used the thermal measurements from KING shot as a principal data point for, "High Altitude Effects on Blast-Thermal Partition of Energy From Nuclear Explosions and Associated Scaling Laws," Dr. Frank H. Shelton, Sandia Corp. Report 2969 (TR). September 1953, SECRET RESTRICTED DATA. (20)

FIGURE 6-8 MARK-9 GUN WEAPON AND F. H. SHELTON
(MARK-19 WAS A REDESIGN OF THE INTERIOR OF THE MARK-9)

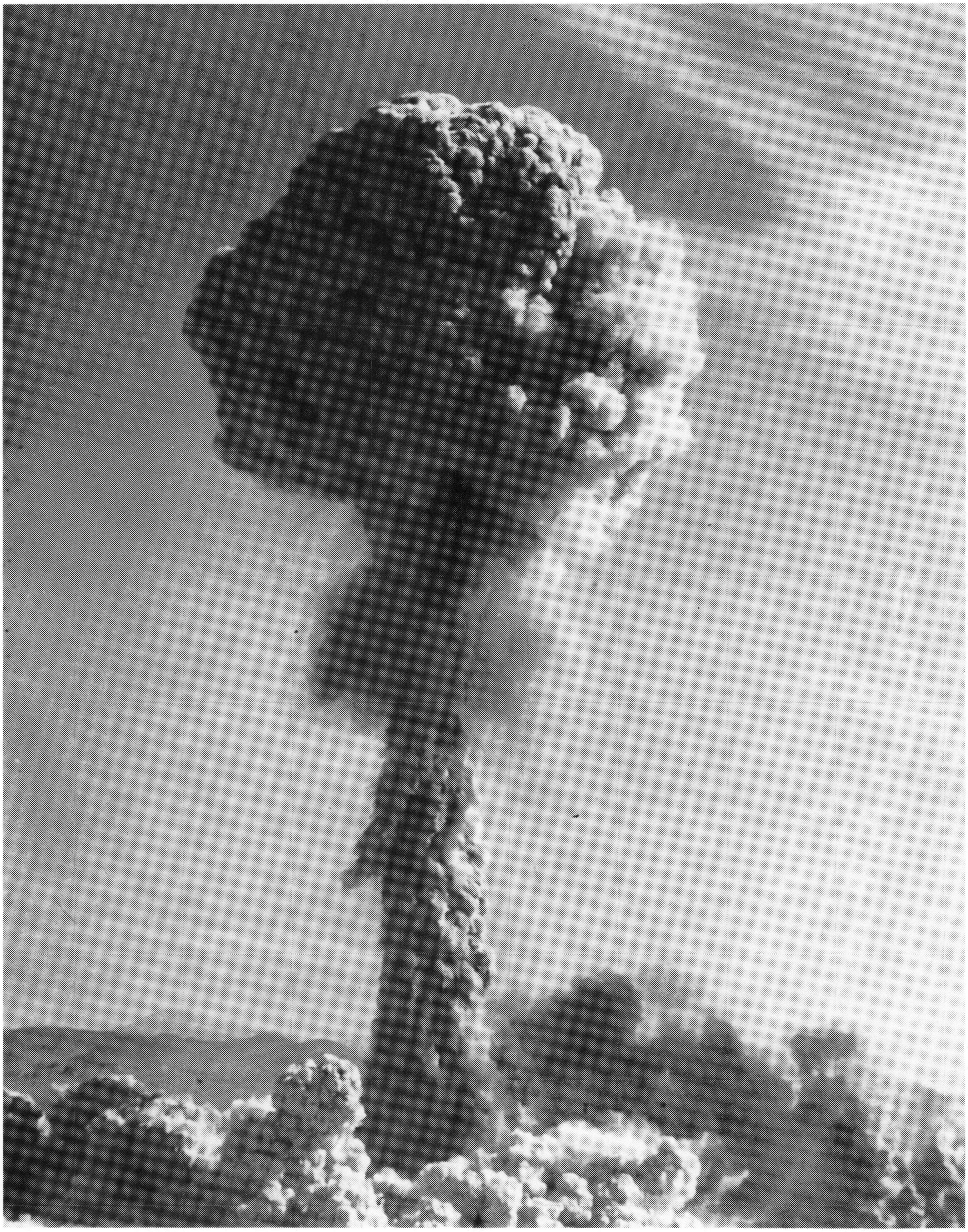


FIGURE 6-11. GRABLE SHOT

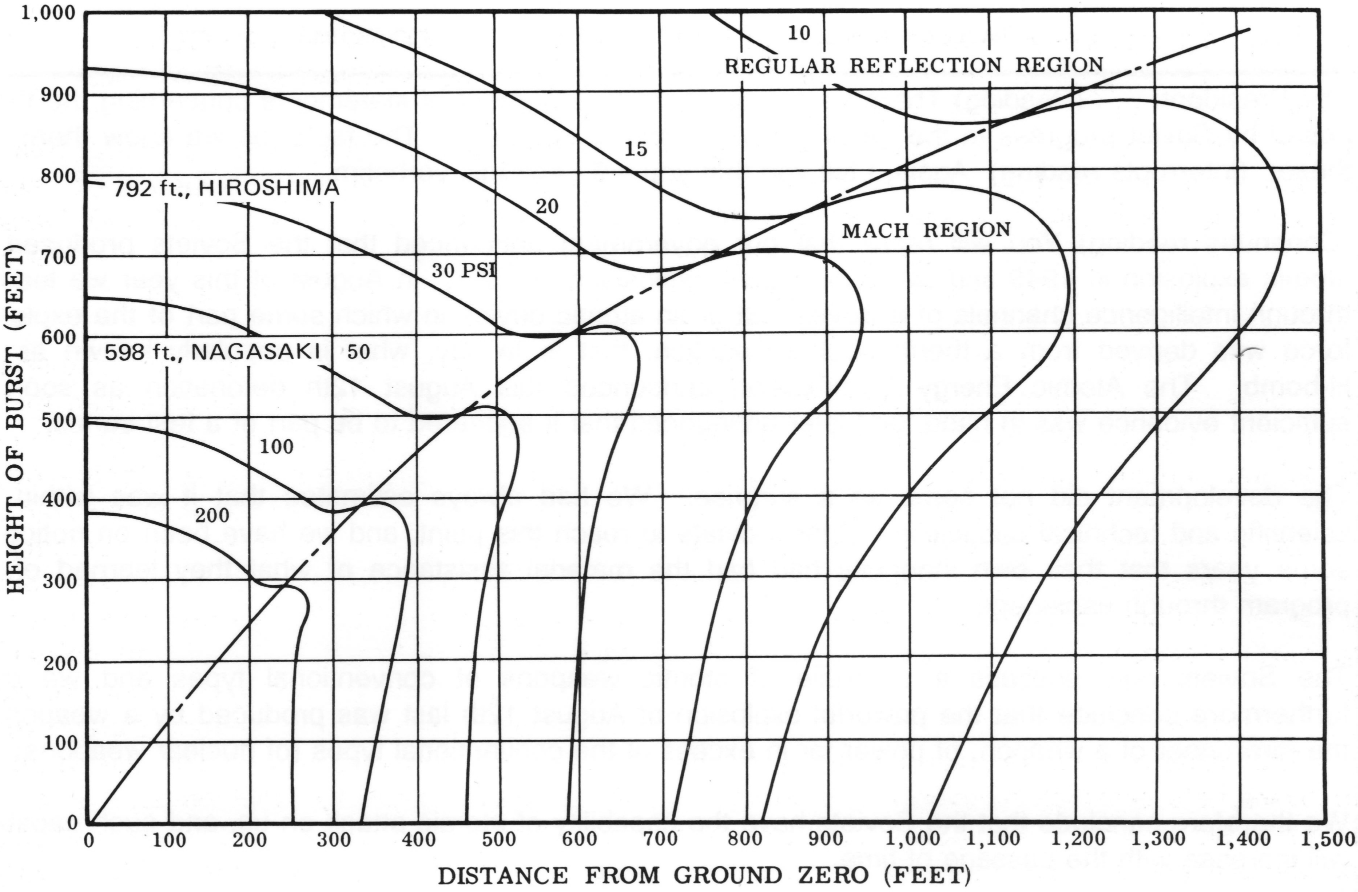


FIGURE 6-12. PEAK OVERPRESSURES ON THE GROUND FOR A 1-KILOTON BURST (HIGH PRESSURE RANGE)

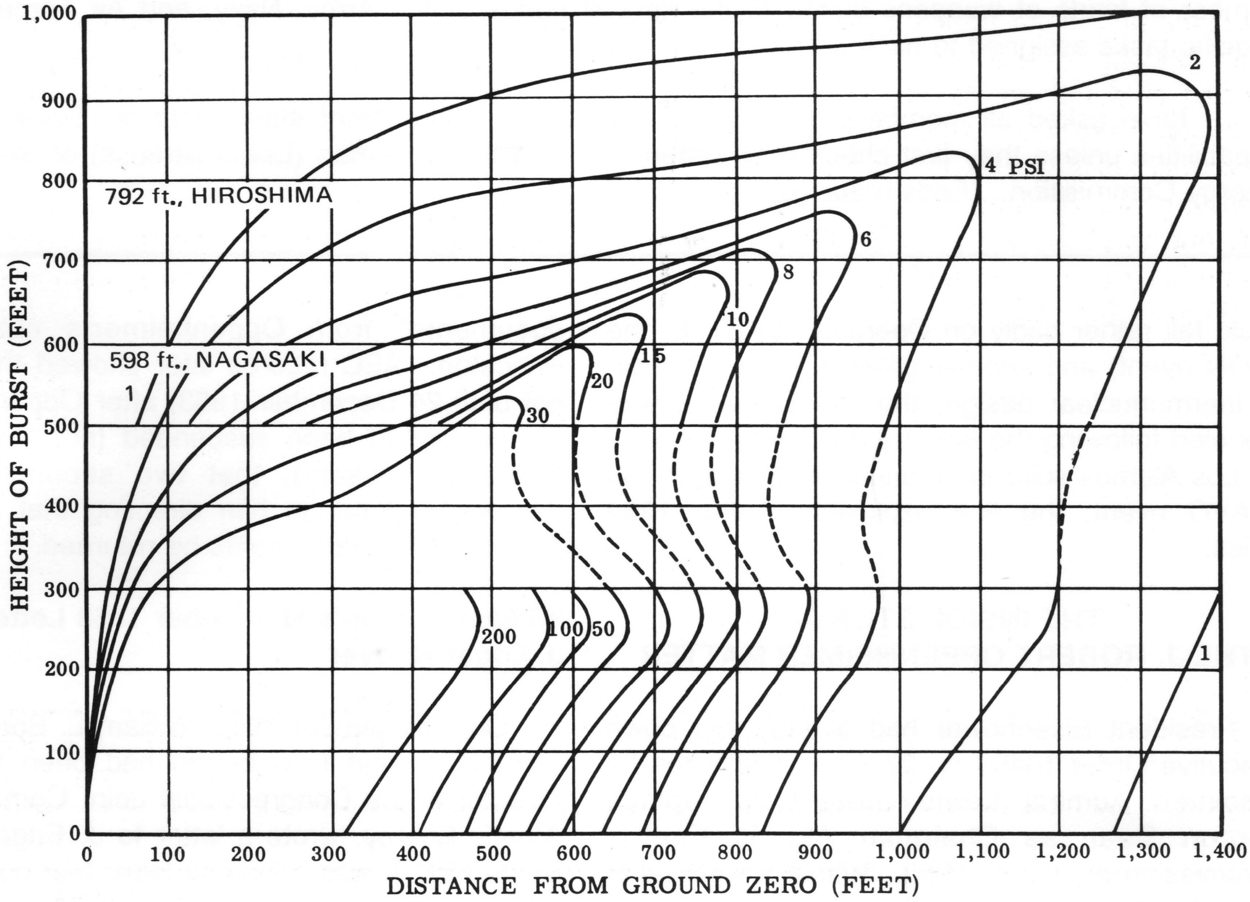


FIGURE 6-13. HORIZONTAL COMPONENT OF PEAK DYNAMIC PRESSURE FOR 1-KILOTON BURST

FIGURE 6-16. SHOT BRAVO, OPERATION CASTLE, PHOTO ON D-23, 5 FEBRUARY 1954, VIEWING NE FROM SHOT CAB AND LINE OF SIGHT EXPERIMENT

4:30 a.m. briefing. Additional search aircraft were sent aloft on headings of 65 degrees; that is, northeast of Bikini out to about 600 nmi. At 4:30 a.m. "no significant changes" in the winds had occurred since midnight, except at Bikini the lower level winds had shifted to more "northerly and westerly components." The ships containing the personnel that had been evacuated from Bikini were moved from 30 miles to a position 50 miles southeast of Bikini. The command ship, USS Estes, remained within the 30 mile or so range in order to maintain good UHF communications with the occupied firing bunker on Nan island at the southeast corner of Bikini Atoll.

BRAVO--BRAVO!

At 6:45 a.m. on 1 March 1954, the firing signal was sent to the thermonuclear device on the sandspit off Charlie Island, and the explosion released the energy equivalent of 15 million tons (MT) of TNT, the largest yield ever tested by the U.S. The test yield for BRAVO, a fusion-fission "small" weapon, was surprisingly large compared to a theoretically estimated yield of up to 6 MT. In a few seconds, the hemispherical fireball grew to nearly 3 miles in diameter and a crater that was about a mile across and 240 feet deep was gouged out of the coral reef off Charlie Island. During the first minute, the blast wave from the nuclear explosion had expanded outward from the burst point, stripping the nearby islands of all their vegetation. The blast wave, upon reaching Nan Island 14 nmi from ground zero, caused considerable damage to the evacuated camp and its lightweight temporary buildings.

The thermal pulse and light from the fireball were visible for almost a minute on Rongerik, 135 miles to the east of the burst. The illumination of

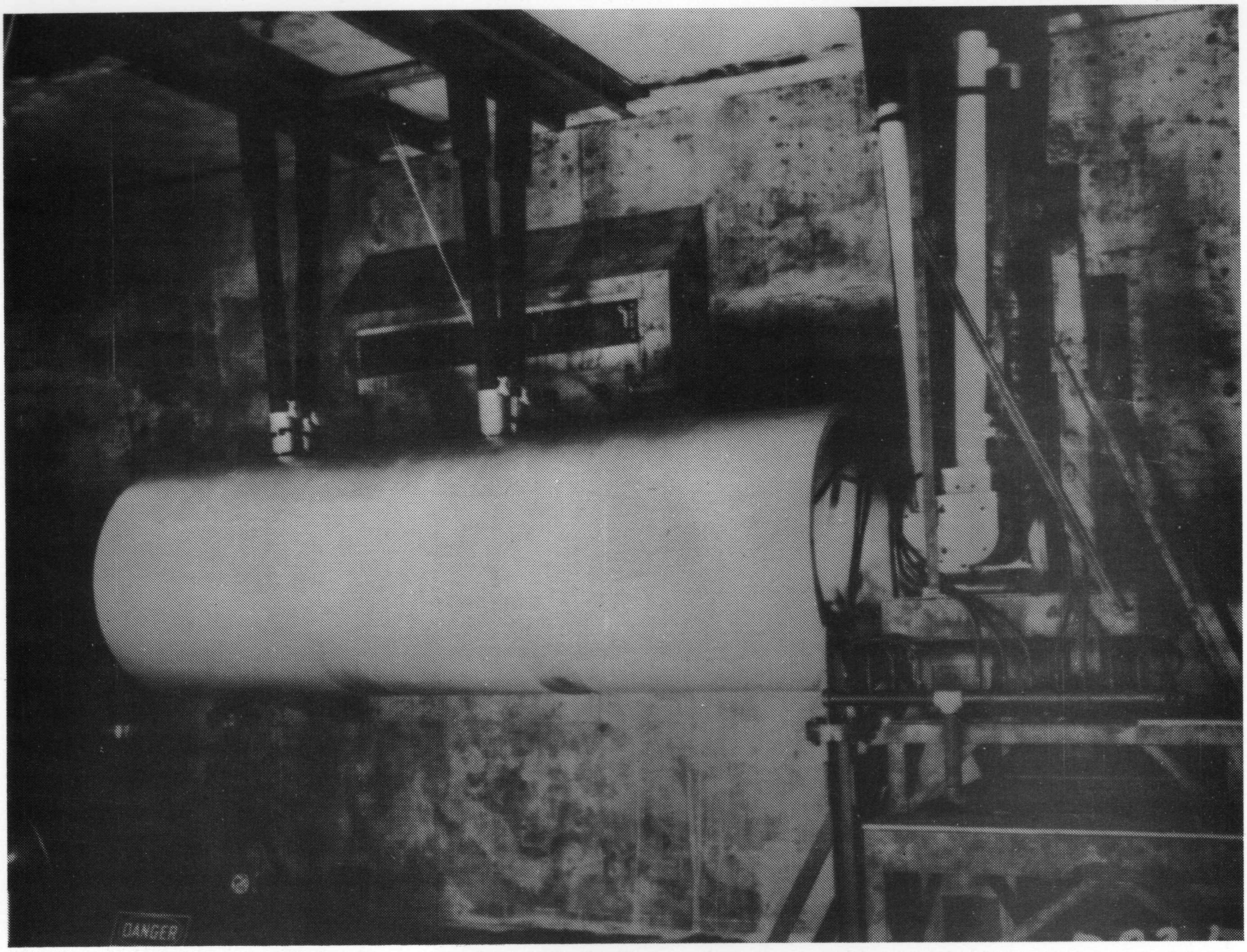


FIGURE 6-17. SHOT BRAVO, NUCLEAR DEVICE ON D-1, 15 MEGATONS

BRAVO was also observed on a Japanese fishing boat 85 nmi east-northeast of Bikini. The boiling luminous gases rose to about 45,000 feet in 1 minute, and the pulverized coral from the crater was sucked up into the nuclear radiation cloud that was already more than thirty miles across. The cloud continued to rise and grow, during which the cloud top reached to almost 114,000 feet in about 4 minutes. (Figures 6-20, 6-21, 6-22, early shot, later cloud, reef crater).

Fallout--Fallout!

At the firing bunker on Nan Island the radiation readings began to rise within one-half hour after the burst and by 1 hour had reached 250 roentgens per hour (R/hr). The personnel who were within the bunker were well shielded, however, and the peak reading there was 0.035 R/hr. At about 8 a.m. the JTF-7 fleet off of Bikini began to receive fallout in the form of gritty, snow-like material. After several hours, the snow-like material stopped falling on the fleet, which indicated that the cloud dispensing these particles was probably about 100 miles across and moving eastward. The time of the fallout passage over the inhabited island of Rongelap, 100 nmi east of Bikini, is not known very well, but the arrival of the fallout at Rongerik, 135 nmi east, was noted by the 25 men of the 6th Weather Squadron who were stationed there.

While a number of early attempts were made to construct a fallout contour map for the BRAVO shot, it was not until after the 1956 REDWING series, with its extensive fallout documentation program, that reasonably correct characterization of the BRAVO fallout pattern versus time could be developed.

Fallout reached the Japanese fishing boat at about 8:15 a.m. The crew, most of whom were topside, had begun to reel in their long fishing lines from the sea, soon after the shock wave

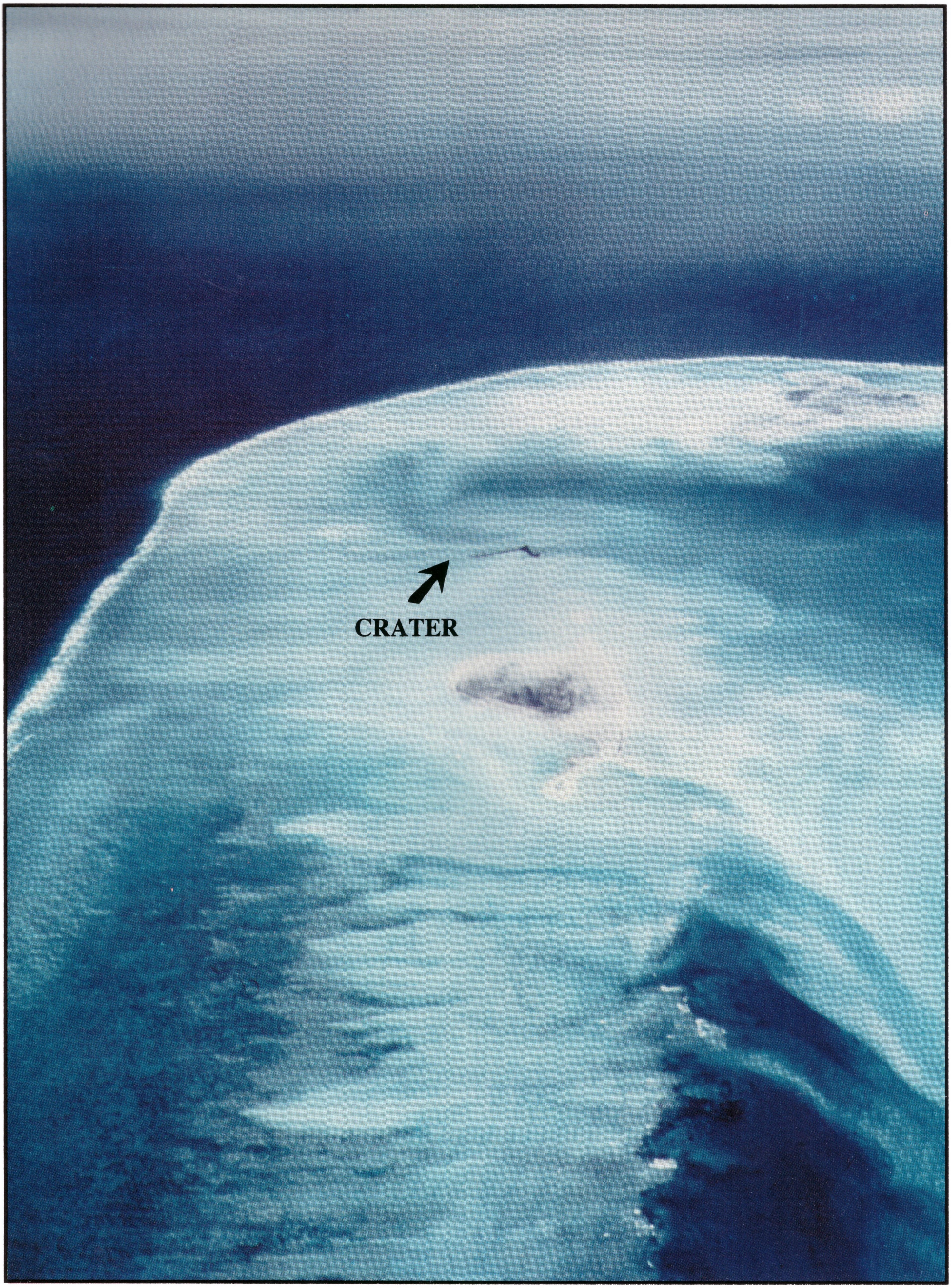


FIGURE 6-22. SHOT BRAVO - CRATER

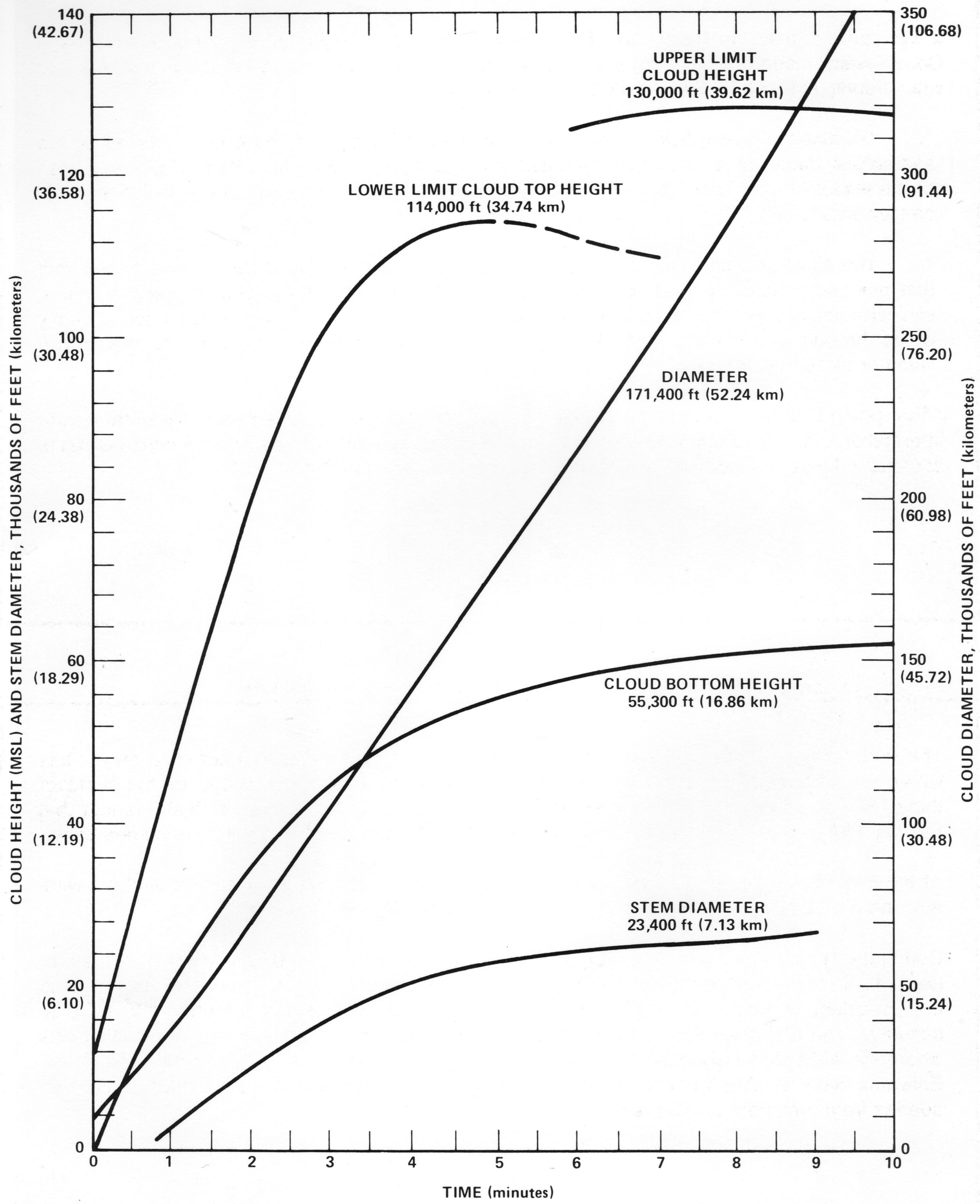


FIGURE 6-23. SHOT BRAVO - CLOUD DIMENSION

TABLE 7-4. TEAPOT MILITARY EFFECTS TOWER (MET) SHOT

PROGRAM 1 - Blast Pressure Measurements:

Project 1.2	"Shock Wave Photography," WT-1102, On Shot 12 an extensive precursor developed over the asphalt area and to lesser extent over the desert area, dust obscured the view of the water surface, Naval Ordnance Laboratory, Silver Spring, Maryland, J.F. Moulton Jr., Project Officer.
Project 1.5	"Preshock Sound Velocities Near the Ground in the Vicinity of an Atomic Explosion," WT-1104, Shot 12 results were not definitive, Navy Electronics Laboratory, San Diego, California, R.C. Loughlin, Project Officer.
Project 1.10	"Overpressure and Dynamic Pressure Versus Time and Distance," WT-1109, Shot 12 measurements on desert, asphalt and water surfaces, Stanford Research Institute, Menlo Park, California, and Office of Naval Research, Washington, D.C., L.M. Swift, Project Officer.
Project 1.11	"Special Measurements of Dynamic Pressure versus Time and Distance," WT-1110, Several types of dynamic pressure gauges were used, including Snob (gas dynamic pressures only) and Greg (dust plus gas dynamic pressures) over desert, asphalt, and water surfaces, Sandia Corp., Albuquerque, New Mexico, J. Banister, F. Shelton.
Project 1.12	"Drag Force Measurements," WT-1111, drag forces on spheres and cylinders were measured on Shot 12, Naval Ordnance Laboratory, Silver Spring, Maryland, J.F. Moulton, Project Officer.
Project 1.13	"Dust Density versus Time and Distance in the Shock Wave," WT-1113, On shot 12 the higher than expected shock front velocity and material velocity hampered the sampling technique, U.S. Army Chemical Warfare Laboratories, Army Chemical Center, Maryland, E.H. Bouton, Project Officer.
Project 1.14	"Transient Drag Characteristics of Spherical Models," WT-1114, Pitot-static gauges responded differently than a force gauge sphere to dust loading, Ballistic Research Laboratories, Aberdeen, Maryland, J.J. Meszaros, Project Officer.

BRAVO fallout conditions. (Figures 7-17 and 7-18, Eniwetok and Bikini.)

The Department of Defense had marshaled an extensive fallout measurement program for REDWING, and it appeared risky to dedicate all that effort to the ZUNI event, knowing that any event might fail. I made a recommendation to CJTF-7, Admiral Hanlon, that another nuclear test, specifically the UCRL TEWA shot (a development companion to ZUNI with different amounts of fission) be moved from deep Bikini lagoon water to a position as close to the north Bikini reef as possible. Detonated in shallow lagoon water, the coral reef material would enhance the formation of local fallout from the TEWA event. After a brief consultation between Admiral Hanlon and Bill Ogle, the recommendation was accepted and put into the REDWING operational plans. (Figure 7-19, REDWING participation certificate.)

OPERATION REDWING--1956 PACIFIC PROVING GROUNDS

Operation REDWING was a 17-detonation nuclear weapon test series (see Table 7-5) held at the Atomic Energy Commission's Pacific Proving Grounds in the spring-summer of 1956. The REDWING series was planned primarily to test high-yield thermonuclear devices that could not be tested in Nevada. The development and testing of these devices, which generate their explosive power through the fusion or joining of hydrogen atoms, began in the U.S. in 1950 and advanced to the stage that one of the nuclear weapons tests planned for REDWING--the CHEROKEE event--would be dropped from a B-52 Strategic Air Command (SAC) bomber. This thermonuclear bomb drop was seven months after the Soviet Union had dropped its own H-bomb from a strategic bomber.

The U.S. CHEROKEE event, although sponsored as a nuclear weapons effects event by the Department of Defense, was probably more a demonstration to the world of the aircraft deliverability of U.S. H-bombs than an experiment. I watched the CHEROKEE event along with a group of 15 U.S. newsmen, the first such group invited to view a Pacific nuclear weapon test since 1946 (Bikini ABLE-BAKER, see Chapter 2).

Further American nuclear weapon testing was absolutely necessary, Strauss, Chairman AEC, told Eisenhower, as plans progressed in early 1956 for the spring-summer Operation REDWING. One of the objectives of those tests was a new H-bomb configuration that would fit into a strategic bomber (see Figure 6-24, Mark-17, H-bomb). Another objective was a smaller warhead to fit into the nose cone of an Inter-Continental Ballistic Missile (ICBM). Eisenhower was very hesitant, but when in March 1956, the Soviets undertook another series of nuclear tests, the President gave his final approval to conduct Operation REDWING. In doing so, Eisenhower pointed out in his 25 April 1956 news conference that without the H-bomb, the guided missile (ICBM), would amount to nothing, and if we stopped nuclear tests, then we would have to stop work on the missiles. (Q)

I stopped over in Honolulu on my way to the Pacific Proving Grounds for the REDWING nuclear tests and read in the local newspapers of President Eisenhower's news conference of 25 April 1956. The first question by the newsmen concerned nuclear testing and disarmament issues. Most of us were appalled by Stassen's discussions with Khrushchev in London on disarmament issues before the negotiations had even begun. (Table 7-6, President's news conference.)

Operation REDWING was the sixth nuclear weapon test series to be conducted by the United States in the Marshall Islands. During the fifth series in 1954 a serious fallout contamination incident occurred (CASTLE BRAVO, see Chapter 6) that involved not only U.S. personnel, but also Marshall Islanders and Japanese fishermen. Because of the unfavorable effect of this 1954 incident on world opinion, the U.S. government recognized the need to issue a statement that specifically addressed health and safety concerns. A draft press release was widely circulated in the AEC and DOD for our comments in early April 1956. The joint DOD-AEC press release was

(Q) Soviet Union Nuclear Tests - spring 1956:
21 March 1956, atmospheric test, detonated a few days before, announced by AEC.
2 April 1956, atmospheric test, detonated a few days before, announced by AEC.

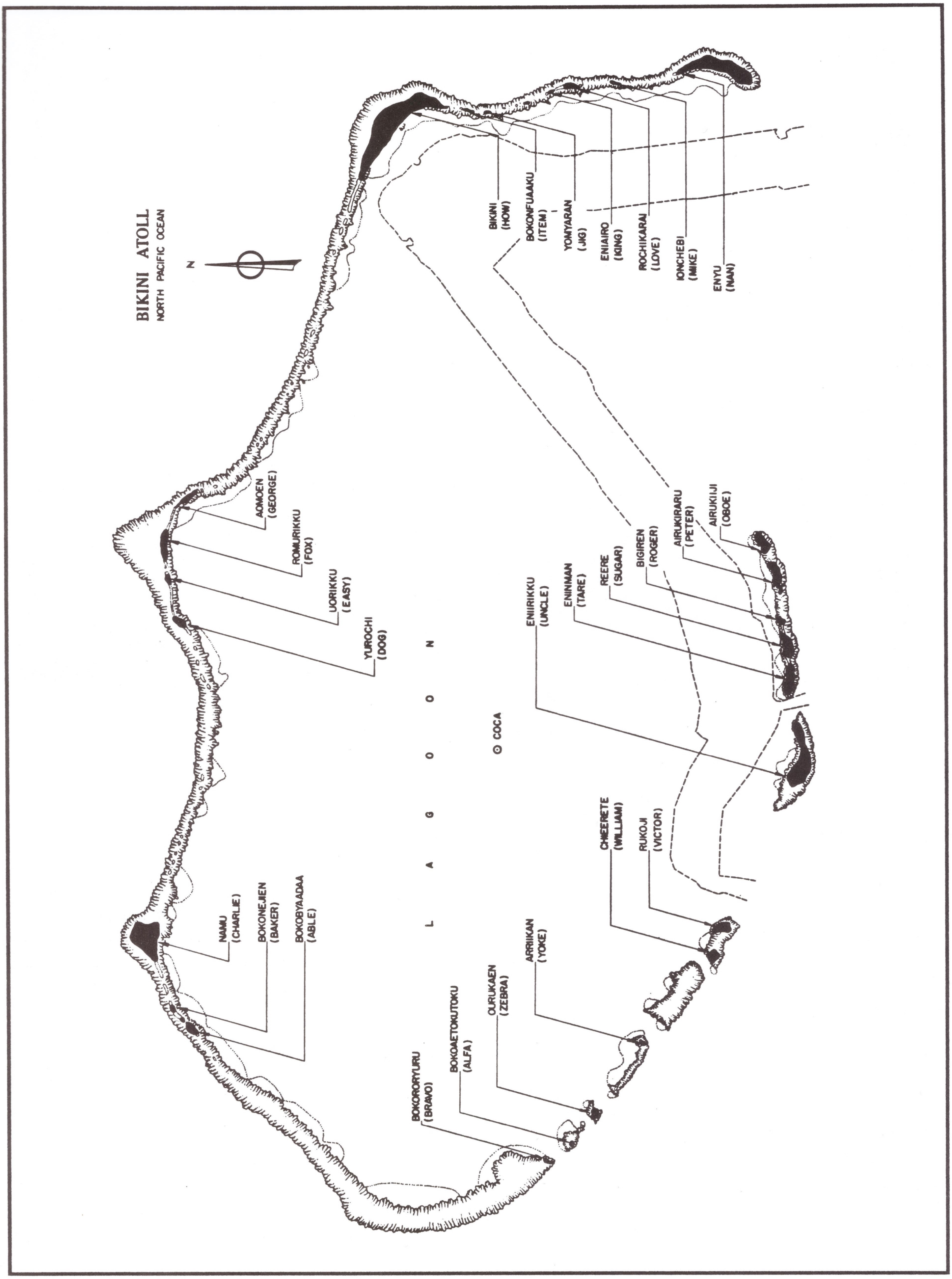


FIGURE 7-18. BIKINI ATOLL 1955

In May 1956, members of a University of California Regents committee accompanied E.O. Lawrence to the Pacific Proving Grounds to review the ZUNI hydrogen-fusion nuclear weapon test. Left to right are: University of California Vice-President James H. Corley; UCRL Physicist Harry Keller; Regents Gerald Hagar and Victor R. Hansen; UCRL Physicists William McMaster and Gerald Johnson, in front of Brigadier General Alfred D. Starbird (person to Starbird's right is unknown); Ernest O. Lawrence; UCRL Physicists Carl Haussmann and Charles Blue; UCRL Director Herbert York; Regent Earl J. Fenston.

FIGURE 7-23. UCRL GROUP AT PACIFIC PROVING GROUNDS

that the CHEROKEE shot was off target somewhere to the northeast of Charlie island. He had arranged for a helicopter to take me, Colonel Woodward, and an H&N engineer with a surveying transit to go up island to try and triangulate the actual burst point, which was out to sea some place. We stopped at several islands east of Charlie, and it was noticed that the Air Force structures were still standing, but with some sidings removed to the north. Finally, on Charlie island it was apparent from various blast indications that the burst had occurred about 20,000 feet (about 4 miles) to the northeast. On return to Nan island, we prepared a message for Gaelen to send over to Headquarters JTF-7 at Eniwetok. (Figure 7-25, Gaelen Felt.)

I knew the message on the CHEROKEE bombing error would be forwarded by Admiral Hanlon to the Joint Chiefs of Staff in Washington. I also knew that my friend, Don Quarles, Secretary of the Air Force would be disappointed in the turn of events. He would probably have to go over to the White House and inform Eisenhower of the situation. I made a mental note to go by and talk to Don as soon as I got back to Washington and explain that Brigadier General "Blackie" Samuels had been on the radio to the drop aircraft continuously during the bombing run, giving direct orders to the bombardier.

A couple days after CHEROKEE, we were amused by the newspaper accounts of the shot, which described it as being "the largest ever conducted in the Pacific." Unclassified accounts of CHEROKEE surmised that the yield was 10 MT, which was fine with all of us who knew the actual explosive power, and we hoped that impressed Khrushchev.

ZUNI Event

ZUNI was a test of a large yield thermonuclear device, designed and developed by UCRL, that required an island to support the large amount of diagnostic instrumentation. Real estate was scarce in the Pacific Proving Grounds, ZUNI being the one event at Bikini to crater out a piece of the island on Operation REDWING. Because of its yield and island configuration, ZUNI was the primary event for fallout documentation on the operation. ZUNI event would turn out to be the most thoroughly documented fallout shot measured during all the United States' weapon

FIGURE 7-24. OPERATION REDWING CHEROKEE SHOT

FIGURE 7-25. GAELEN FELT

testing in the Pacific from 1946 (Bikini ABLE/BAKER) through 1962 (Operation DOMINIC).

About two weeks before the readiness date for ZUNI, we toured the shot island (Tare) and the shot cab with Walter Gibbins, UCRL Deputy on Task Group 7.1 (Appendix B, 7.1 organization). It was interesting to walk the area and note that ZUNI ground zero was near the old KOON crater produced by a UCRL event on Operation CASTLE. (Figure 7-26, ZUNI cab.)

Reviewing the fallout documentation plans for ZUNI shot, I spent some time on one of the three fallout collection ships that had been modified by the U.S. Naval Radiological Defense Laboratory (NRDL) at Hunters Point in the San Francisco bay area. With Commander Don Campbell, Program 2 Director, we visited the YAG-39 (USS George Eastman) which had been modified to permit operations in the fallout area from its heavily

shielded control room and was to be positioned in the fallout zone (along with the YAG-40 and USS Crook County) prior to arrival of fallout. It was only after spending some time on one of the YAGs that I appreciated the potential contributions that ships could make in our all-out effort to document fallout from large yield thermonuclear weapon explosions. Paul Tompkins and Gene Cooper, heads of NRDL, and I reviewed their plans both in my office and in theirs for modifying the ships for fallout collection. I was more impressed with the AFSWP costs and long lead times for modifications in the naval ship yards. Out in the Pacific, the modified ships were truly technological innovations. Victor Van Lint spent a large part of his time out in the Pacific coordinating the plans for the Scripps Institute of Oceanography's boat (the MV Horizon) to service the 16 deep moored "skiffs" that were instrumented to collect fallout data in the area north of Bikini Atoll.

As shot day for ZUNI event approached, everyone was evacuated from Bikini Atoll, including those who had occupied the Control Point on Nan island during the CHEROKEE shot. The Task Group 7.1 Command staff and key scientific personnel were aboard the USS Curtiss when ZUNI was detonated by a radio signal at 5:56 a.m. on 28 May 1956. Ground zero was near the KOON crater that was made on Operation CASTLE. The yield of the University of California Radiation Laboratory (UCRL) ZUNI device was 3.5 MT. ZUNI, with its high yield and surface placement, formed a large crater that chewed out the western end of Tare island, and ejected material was pulled up into the radioactive cloud. As soon as we were able to make an aerial survey of the ZUNI crater, it was flooded by the lagoon waters. Crater dimensions were: radius = 1165 feet, depth = 93 feet (Figure 7-27, ZUNI shot).

The ZUNI radioactive cloud topped at 85,000 feet, with a diameter at that time of 75,000 feet. General cloud movement was to the north at 15 knots, but the lower portion of the stem moved to the west, under the prevailing easterlies, at about the same speed. The 30,000-foot winds turned to the southeast sometime late on shot day, causing light fallout on atolls southeast of Bikini. Heavy radioactivity was measured throughout most of the Bikini Atoll, with readings of 75 R/hr at 4 hours (H+4 along the northern rim of islands). Fortunately, the living area on Nan was only lightly touched by fallout. An H+4 value of 0.003 R/hr was measured. Fallout contours for the ZUNI event are given in Figure 7-28, with all readings being extrapolated back to H+1 hour. Some hot spots of 150 R/hr were noted at about 50 miles north of the shot point. (Figure 7-28, fallout contours, and Figure 7-29, ZUNI crater.)

TEWA Event

(See Figure 7-30 and 7-31, Eniwetok and Bikini Atoll maps for shot locations.)

The UCRL 5 MT TEWA device was fired 21 July 1956 on a barge anchored on the reef between Charlie and Dog islands on the north rim of Bikini Atoll (Figure 7-32,TEWA barge). TEWA was a companion event to ZUNI for documentation of fallout from large yield thermonuclear weapons (Figures 7-33 and 7-34, TEWA device and shot cloud). In early Operation REDWING planning, the location of the TEWA event had been moved from deep lagoon waters to as near the coral reef as possible. I had always hoped that it could be anchored in water that was less than the 24.7 feet which occurred on the final placement. Total weight of the barge was 440,000 pounds, including 410,000 pounds of steel, all of which contributed to the fallout material, as well as the coral reef material created by the explosion. Crater measurements were: radius = 1915 feet, depth = 133 feet, with a total of 740 million cubic feet of material being ejected in the formation of the crater. The fallout pattern documented for TEWA is given in Figure 7-35. While the yield of TEWA (5 MT) was larger than ZUNI (3.5 MT), it was observed that the down wind "hot spot" for TEWA (1000 R/hr) was much higher than on ZUNI (150 R/hr). The difference was primarily due to the higher percentage of fission yield for TEWA as compared to ZUNI. (Figure 7-35, TEWA fallout contours, and Figure 7-36, TEWA crater.)

SEMINOLE Event

The SEMINOLE device was detonated on the western end of Irene island (Eniwetok Atoll) at 12:55 p.m. on 6 June 1956 during Operation REDWING. SEMINOLE was a LASL sponsored event with a low yield of 13.7 KT. However, because the device was detonated within a large water filled tank, it probably had an increased

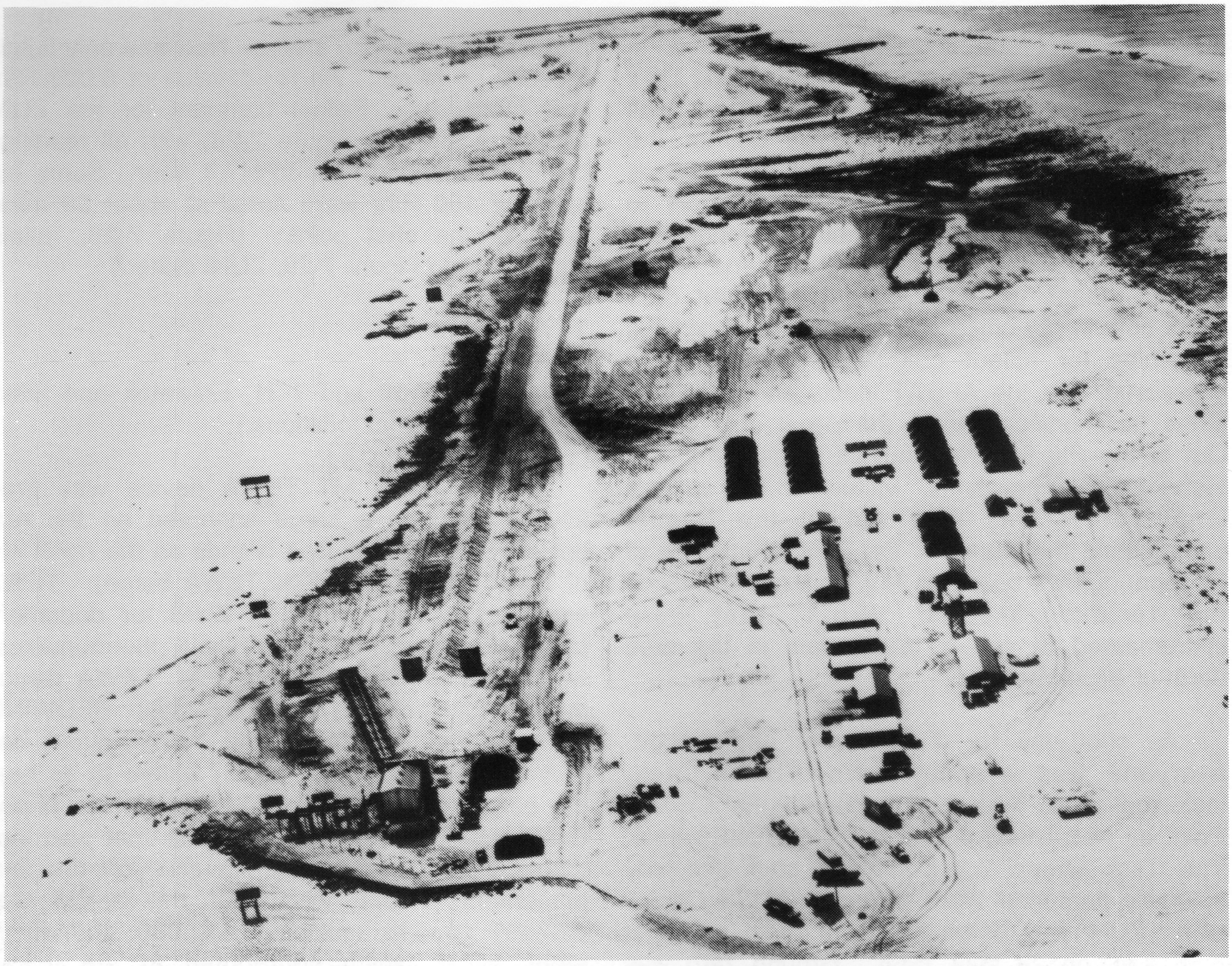


FIGURE 7-26. ZUNI CAB AND INSTRUMENTATION (D-30, VIEWING EAST, EDGE OF CASTLE KOON CRATER)

FIGURE 7-27. ZUNI SHOT VIEWED FROM ENEU ISLAND

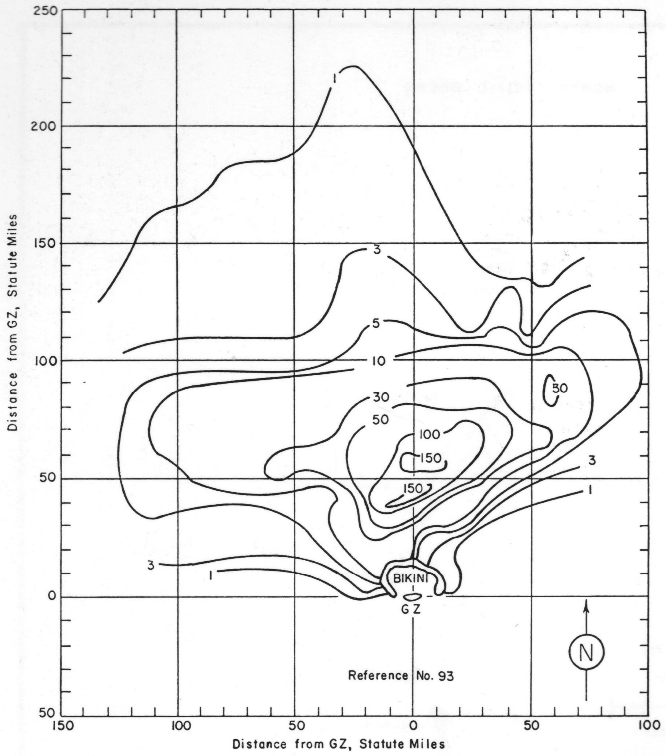


FIGURE 7-28. ZUNI FALLOUT CONTOURS

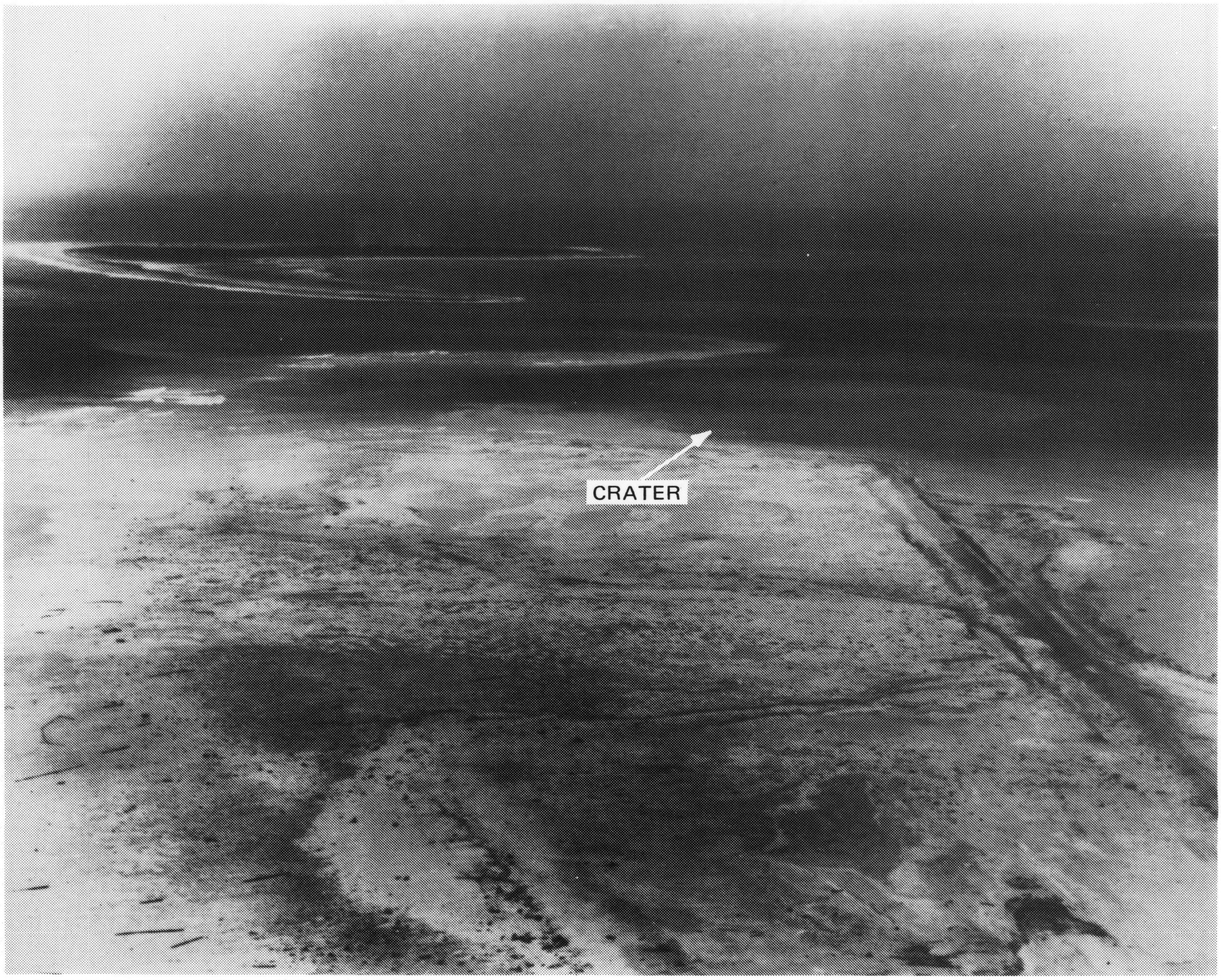


FIGURE 7-29. ZUNI CRATER (H + 10, LOOKING WEST)

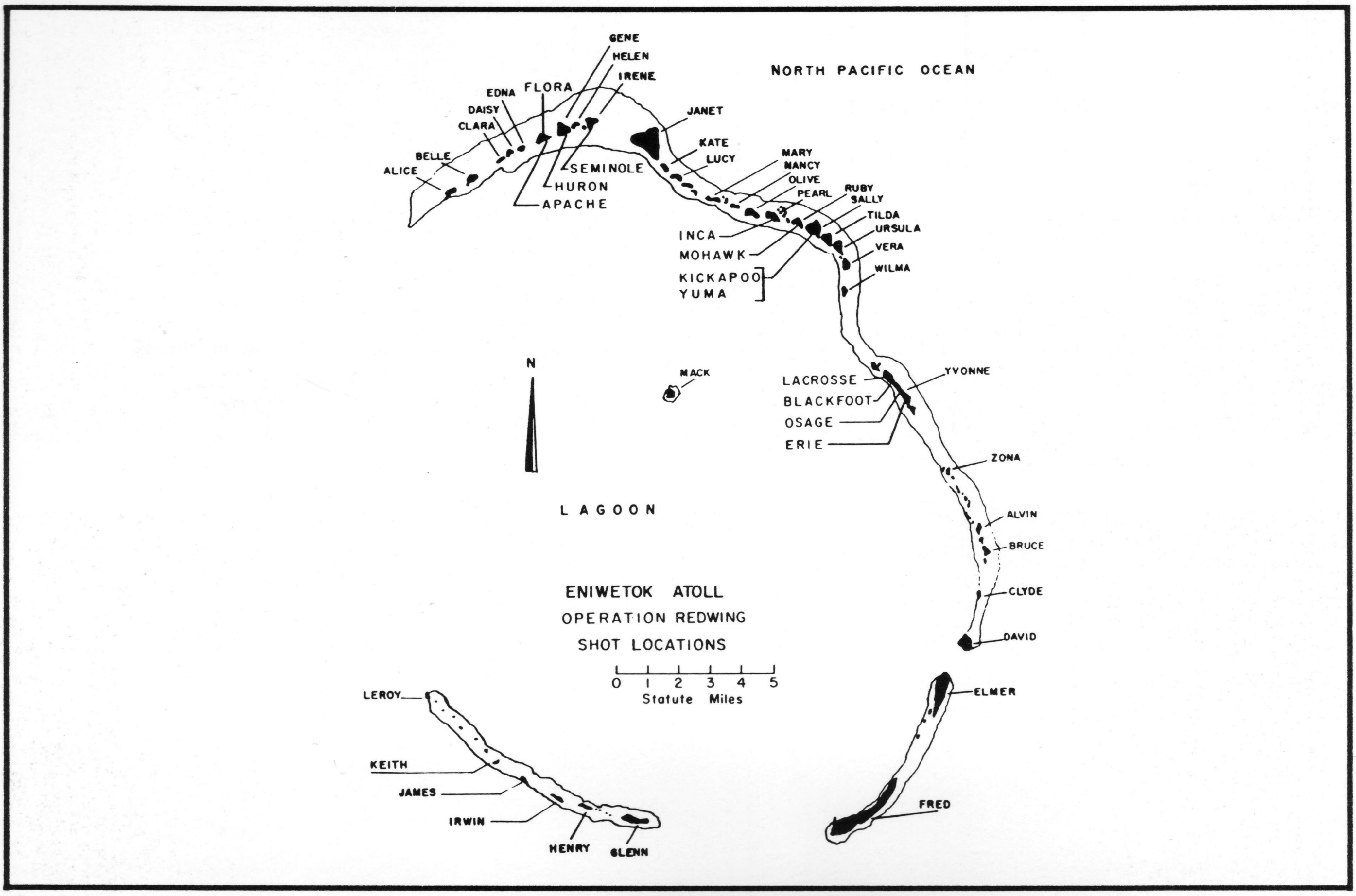


FIGURE 7-30. ENIWETOK ATOLL SHOTS

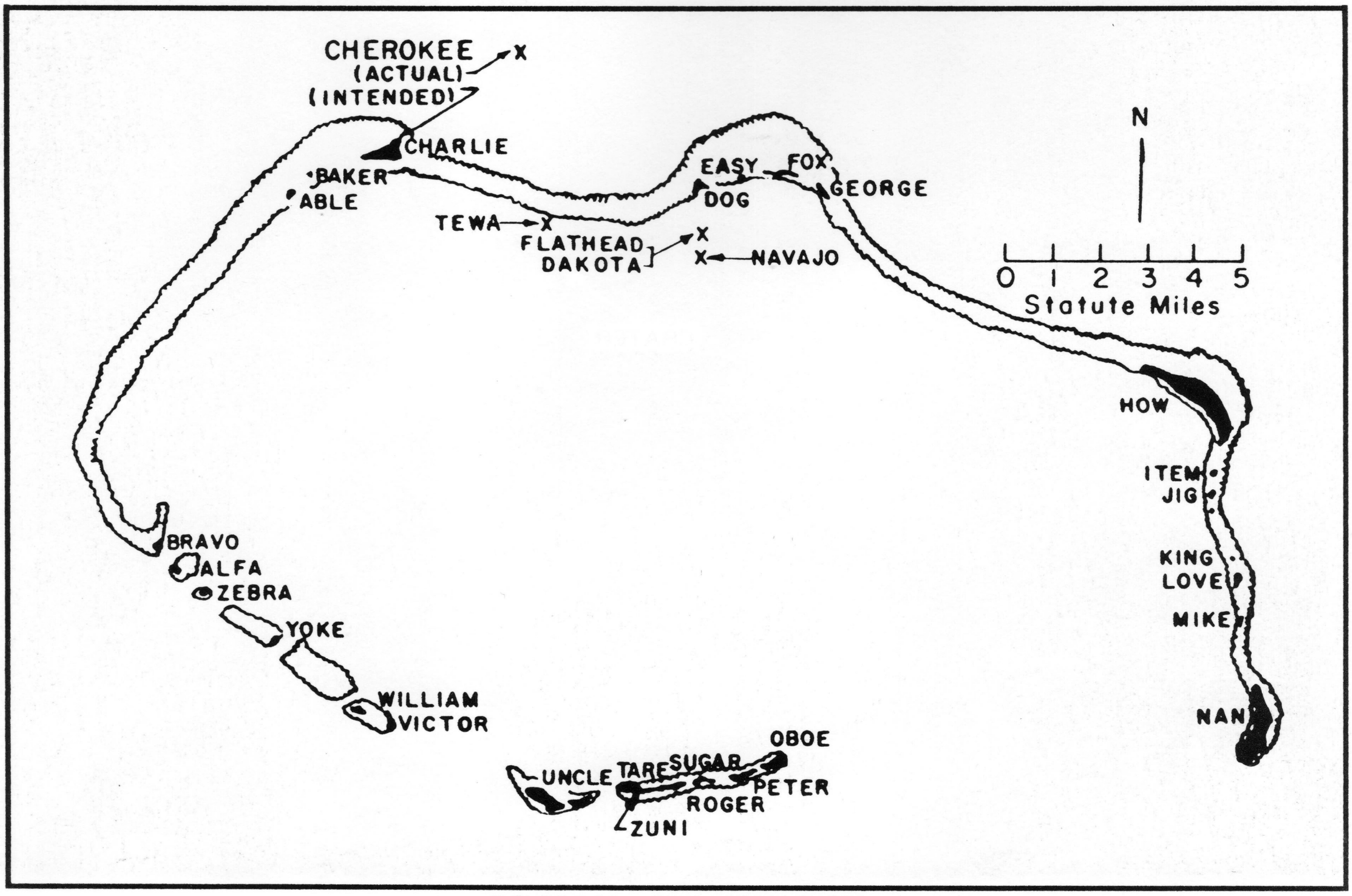


FIGURE 7-31. BIKINI ATOLL SHOTS

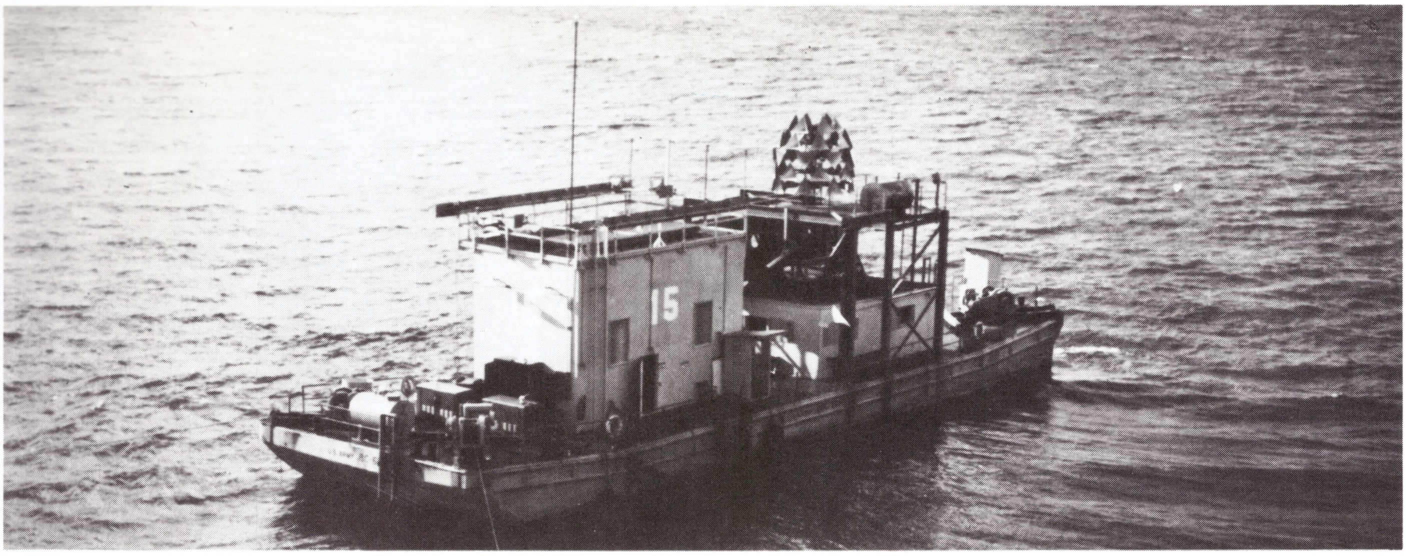


FIGURE 7-32. TEWA PRE-SHOT BARGE (D-1, BIKINI LAGOON BETWEEN DOG AND CHARLIE ISLANDS)

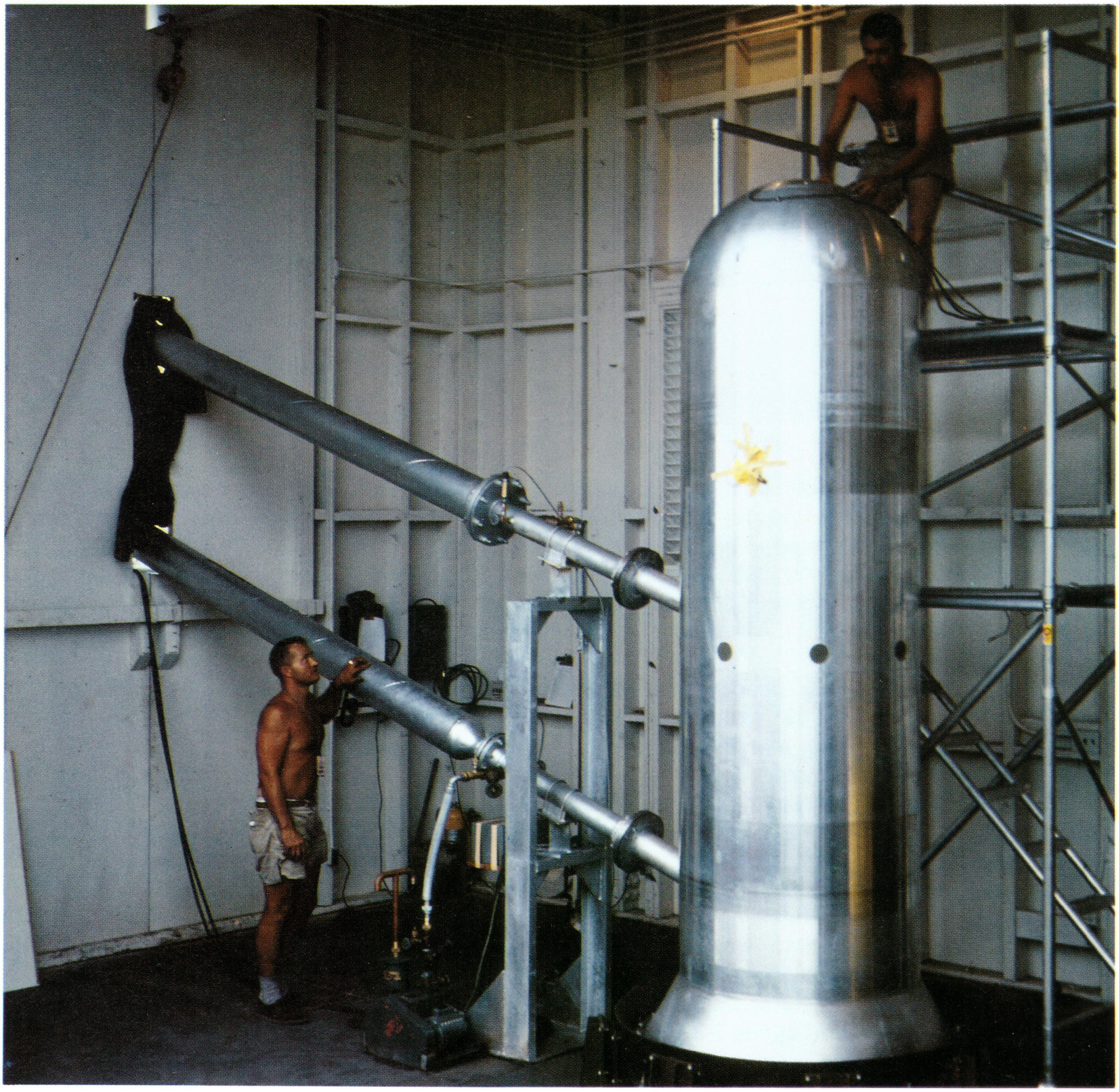


FIGURE 7-33. TEWA DEVICE (D-3, HOB = 8.2' ABOVE WATERLINE)

FIGURE 7-34. TEWA SHOT CLOUD FROM ENIWETOK

amount of energy coupled with the ground, resulting in a larger crater volume as compared with a similar device detonated in air at the same height of burst. (Figure 7-37, SEMINOLE water tank under construction; Figure 7-38, SEMINOLE device.)

The SEMINOLE nuclear weapon was placed inside a 15-foot diameter air filled steel tank, which, in turn, was inside and tangent to the diameter of a 50-foot diameter steel tank. The tanks were connected by a structural steel tunnel with water-tight doors. A 200,000 pound lead shield was positioned directly opposite the device between the two tanks. The total mass of sea water in the large tank, including the flooded access tunnel, at shot time was 2.9 million pounds. The station foundation was a 3-foot-thick concrete slab (1.3 million pounds of concrete and 200,000 pounds of steel). (Figures 7-39 and 7-40, shot and crater.)

SEMINOLE shot had an impressive amount of ejecta at zero time (see Figure 7-38), producing a crater that was: radius = 324 feet, depth = 31.6 feet. (Figures 7-41 and 7-42, pre-shot and post-shot.)

FLYING HIGH WITH A HALF-DOZEN U-2S

The fallout program on REDWING was designed to document local radiation levels for hundreds of miles down wind and for a few days after each nuclear weapon detonation. As the REDWING series progressed, I watched multi-megaton radioactive clouds rise to about 100,000 feet altitude. (Figures 7-43 and 7-44, REDWING shots DAKOTA and APACHE; Figure 7-45, MOHAWK shot.)

The documented local fallout was being carried back to earth on large, solid particles. While it was important to understand the local

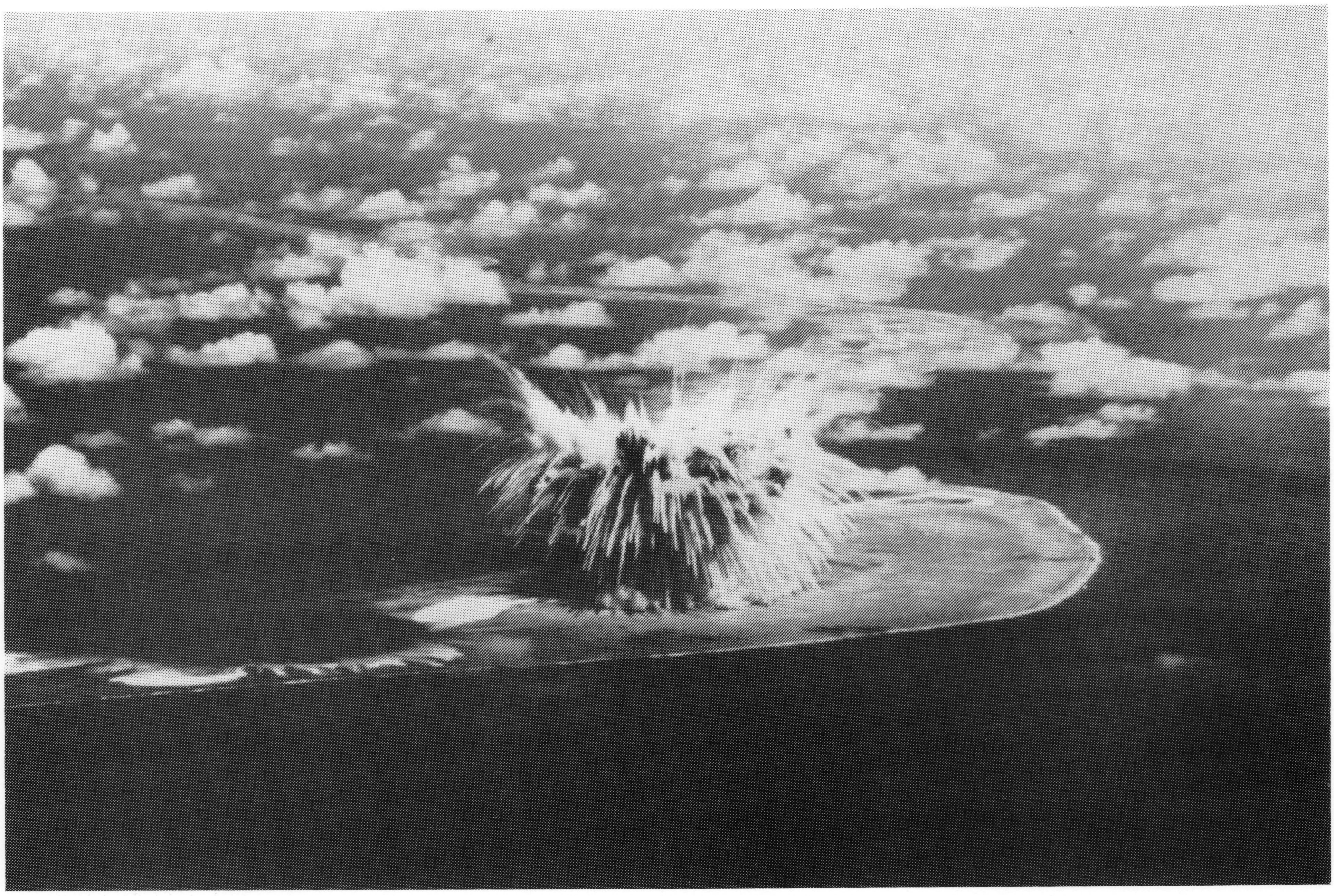


FIGURE 7-39. SEMINOLE SHOT

FIGURE 7-40. SEMINOLE CRATER (D + 19, VIEWING NORTH)

TABLE 7-7. SUMMARY OF PACIFIC CRATERS

OPERATION	EVENT	YIELD (KT)	HOB (FEET)	RADIUS (R) (FEET)	DEPTH (D) (FEET)	RADIUS (R)/(D) DEPTH
IVY	MIKE	10,400	10.0	2,910	187.0	15.6
CASTLE	BRAVO	15,000	7.0	3,255	200.0	13.0
	KOON	150	9.6	495	40.0	12.4
REDWING	LACROSSE*	39.5	8.0	200	55.5	3.6
	ZUNI	3,380	10.0	1,165	113.0	10.3
	SEMINOLE	13.7	7.0	324	32.2	10.1
	TEWA	4,600	10.0	1,915	133.0	10.4

* Originally, I thought that the small radius/depth = 3.6 for LACROSSE (Similar to Nevada craters R/D = 2.0) occurred because it was not heavily washed by waves after the shot, as the high yield shots were. Now, it is believed that the large R/D ratios in the pacific craters are due to pressure collapse of the porous coral material, and not due to ejecta from the crater. (See Table 7-3, Nevada Test Site Craters.)
(Reference 16: Table 1-1, "Geologic And Geophysical Investigations Of The Eniwetok Nuclear Craters," Capt. Byron L. Ristvet, September 1978, AFWL-TR-77-242, Unclassified Most of the REDWING figures also appear in this reference.)

fallout portion of the total nuclear radiation that was produced by the large yield nuclear bursts, I was thinking about the other part of the fission debris that remained in the stratosphere for years and was spreading around the earth. How do you measure that part of the fission debris that slowly settles out of the stratosphere as worldwide fallout? At that time, there was only one kind of airplane that could fly high enough to sample the stratosphere, and that was Kelly Johnson's new U-2 aircraft being built to CIA specifications for overflight reconnaissance of the Soviet Union. (Figure 7-46, U-2 aircraft.)

The Joint Chiefs of Staff, realizing the seriousness and complexity of the worldwide fallout problem, requested in the fall of 1954 (after CASTLE Bravo in the spring of 1954) that the Armed Forces Special Weapons Project (AFSWP) study and evaluate the situation on a continuing basis. After considerable study during 1955, it was decided that the largest uncertainty in the prediction of the distribution and concentration of worldwide fallout debris on the surface of the Earth was the quantity of fission products in the stratospheric reservoir and the rate and mode of its transfer to the biosphere. The AFSWP program became known as the High Altitude Sampling Program or "Project HASP."

Soon after I joined AFSWP in the fall of 1955, Major General Al Luedecke (Chief of AFSWP) brought me into the Top Secret U-2 program that was underway at that time under the immediate supervision of Lieutenant Colonel Howard Rose, AFSWP Radiation Division. Development and availability to AFSWP of the new Lockheed U-2 aircraft made Project HASP a real possibility. It was, however, important to incorporate a sampling system into the U-2 aircraft using a new filter paper with low resistance to air flow, but high efficiency in collecting capability. A contract was initiated with the Institute of Paper Chemistry in September 1956 for development of the filter paper. Prior to the delivery of the six AFSWP U-2s in the summer of 1957, a contract was let in February 1957 with Isotopes, Inc. under the scientific direction of Dr. Laurence Kulp and Dr. Herb Feely. Professor Elliot Reid of Stanford University, one of this country's leading authorities on the application of aerodynamic theory to atmospheric sampling mechanisms, was consulted regarding the design and application of a filter-type sampler for HASP.

President Eisenhower wanted intelligence information from within the Soviet Union; especially early warning on mobilization of troops or aircraft. However, CIA, under Allen Dulles, had been unable to establish an effective spy network in Russia to obtain information on Soviet military build-ups. Eisenhower activated in early 1954 a "Surprise Attack Panel" to advise him on the Soviet surveillance matter. Chairman of the Panel was James Killian, President of MIT. Edwin Land, inventor of the Polaroid camera and winner of a

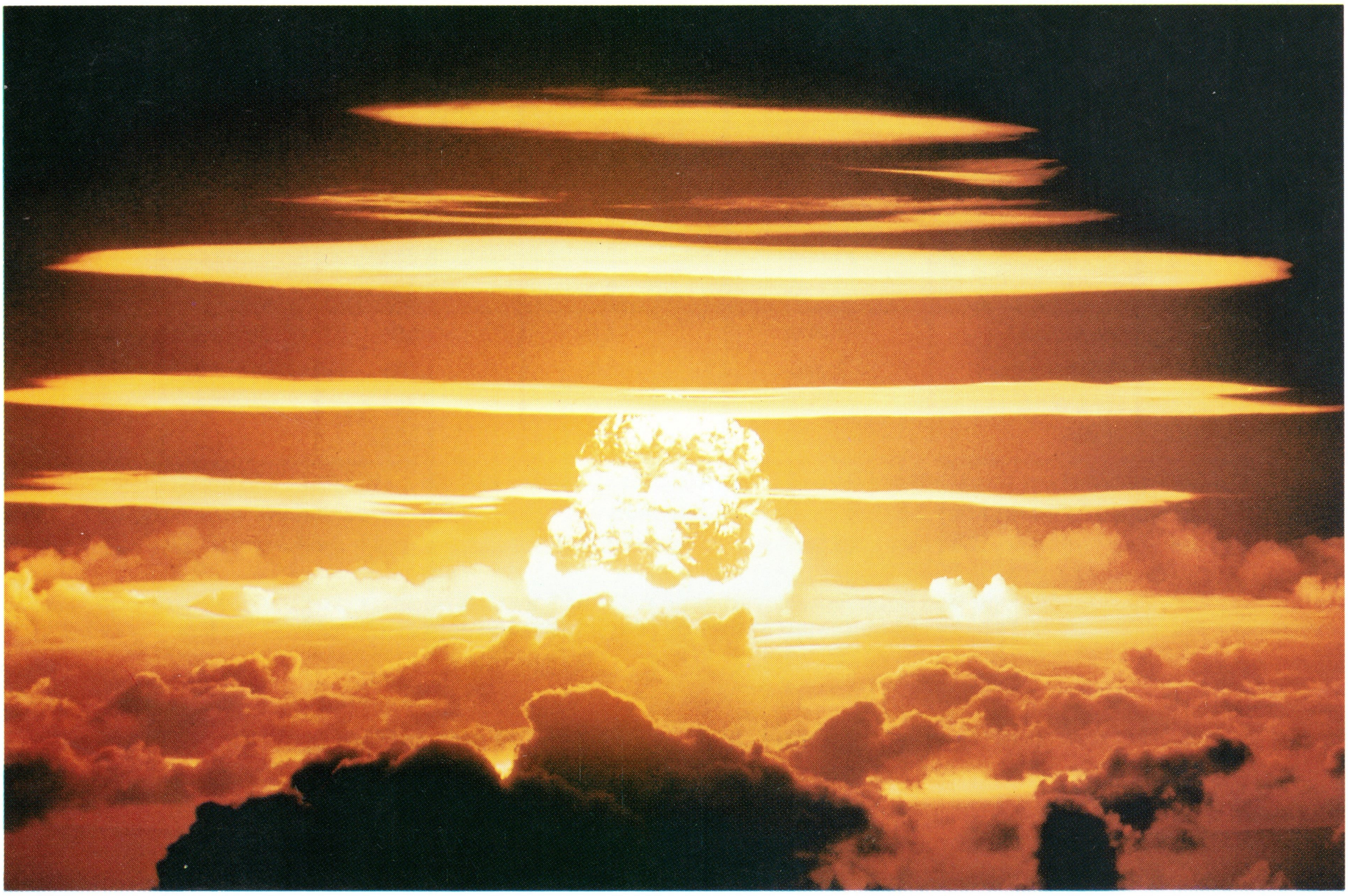


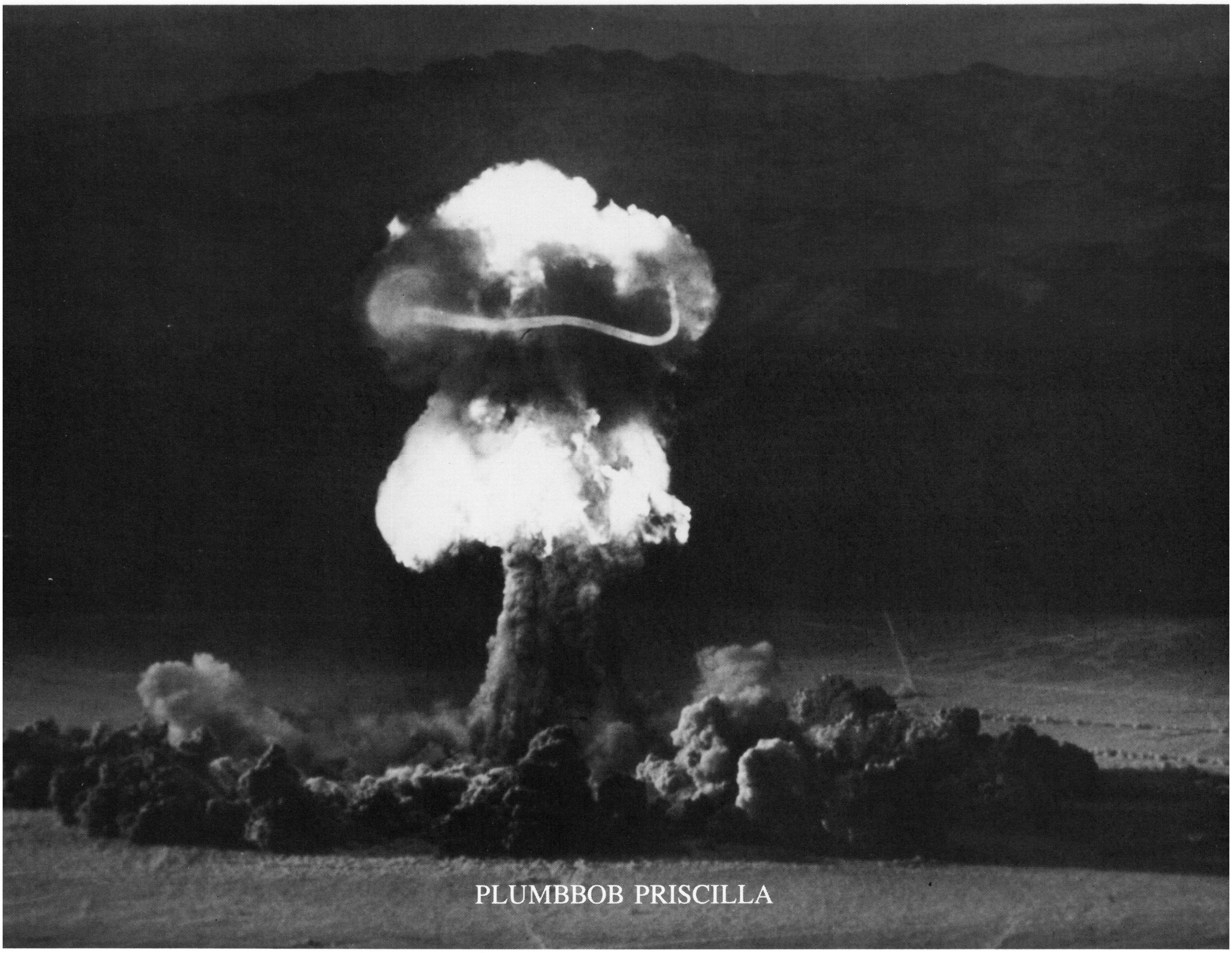
FIGURE 7-43. DAKOTA BARGE SHOT

FIGURE 7-44 APACHE BARGE SHOT

FIGURE 7-45. MOHAWK TOWER SHOT

OPERATION PLUMBBOB
1957

CHAPTER 8



PLUMBBOB PRISCILLA

MAY 10 1957

SCIENTIST DOUBTS FALL-OUT DANGER

Atom Tests Can Be Safe for 40 Years at Present Rate, Pentagon Aide Testifies

NY TIMES

Special to The New York Times.

WASHINGTON, May 9—Atomic testing can be continued at the present rate for another forty to fifty years and not create any serious danger from radioactive fallout, the chief atomic weapons scientist in the Defense Department believes.

This opinion was offered recently by Dr. Frank H. Shelton, technical director of the Armed Forces Special Weapons Project. He gave it when testifying before a House Appropriations subcommittee on the possible dangers to human health caused by the fall-out from atomic explosions. The testimony was released today.

Dr. Shelton was called before the subcommittee to discuss what had been described as a "great deal of concern" being expressed over the long-range effect on the human race of the fall-out. The subcommittee's chairman, Representative George H. Mahon, Democrat of Texas, had noted such "concern."

At one point during the closed door hearing, Mr. Mahon asked:

"Could you not say that at the present rate we could go on for forty to fifty years without serious danger in so far as you know?"

"Yes,"Dr. Shelton replied.

Information 'Meager'

At the same time, Dr. Shelton conceded that information on world-wide fall-out from past atomic tests was "extremely meager." The Defense Department, he said, is taking steps to define more precisely the amount of radioactive debris in the air from atomic tests and the rate at which it is falling to the earth.

Dr. Shelton testified that it would require large nuclear explosions with a yield equivalent to 30,000,000,000 tons of TNT to bring the average concentration of Strontium-90 in human bones up to the maximum permissible concentration. This would be equivalent to 1,500,000 atomic bombs of the size dropped on Japan in World War II.

Strontium-90 is a long-lived radioactive product of a nuclear explosion. In human bones it can produce cancer or leukemia. The maximum permissible concentration of Strontium-90 for general populations has been set at one-tenth of a microcurie for a person. A curie is a technical measurement of radiation, and a microcurie is one-millionth of a curie.

Dr. Shelton said that the maximum permissible concentration was five to ten times below the concentration necessary to produce a "barely detectable increase" in the rate of bone cancer or leukemia. His statement was based on the assumption, challenged by some scientists, that extremely small doses of Strontium-90 will not induce bone cancer.

Dr. Shelton likewise tended to minimize the threat of external radiation from fall-out materials. To increase the world-wide external radiation exposure by 10 per cent, he said, would require atomic explosions with a yield equivalent to 5,000,000,000 tons of TNT. The 10 per cent increase, he said, would be equivalent to the greater natural radiation received as a result of living in Denver instead of at sea level.

In the event of war, Dr. Shelton said, exposure to radioactive fallout can be reduced "very effectively" by even the most simple shelter.

FIGURE 8-4. NEWSPAPER ARTICLE, NEW YORK TIMES, 10 MAY 1957, "SCIENTIST DOUBTS FALLOUT DANGER"

'BRAVO' WAS 66 MILES WIDE

MAY 1 0 1957

H-Test a Close Squeak for Marshall Islanders

WASHINGTON NEWS

Sixty-four Marshall Islanders dusted with "Bikini ashes" from the big H-bomb test of March 1, 1954, are alive today only because they lived on the south side of their native atoll.

If they had lived some 40 miles to the north, all would now be dead. As it was, all suffered radiation injury but have now recovered—as far as detectable effects are concerned.

This and much more about the so-called "Bravo Shot" of the 1954 H-bomb tests in the Pacific was disclosed for the first time in testimony released today by a House appropriations sub-committee.

The revealing testimony was by Dr. Frank H. Shelton, technical director of the Armed Forces Special Weapons Project.

Altho some of the facts reported by Mr. Shelton had been known to reporters, they never had been publicly stated before by any official. For example:

15,000,000 TONS

The power of the March 1, 1954, explosion was "on the order of" 15 megatons, or 15 million tons of TNT.

The Bravo bomb cloud rose to 100,000 feet. Its diameter was 66 miles. The cloud stem was 6½ miles thick.

This was the extremely "dirty" bomb that alerted the world to the menace of radioactive fallout. In all, 239 Marshall Islanders living on atolls east and southeast of Bikini suffered radiation injury.

The worst afflicted were 64 inhabitants of Rongelap, the nearest atoll to Bikini. They lived only on the southern side of their atoll, which is roughly 40 miles in its north-south dimension.

About six hours after the Bravo explosion, "hot" fallout in the form of visible flakes began to fall on Rongelap. By the time their plight was detected, the Rongelapese had been exposed to about 175 Roentgens of radioactivity. It takes about 450 roentgens to kill.

According to Dr. Shelton, if the natives had lived on the north side of their atoll, where the fallout was more intense, "all would have died."

'CLEANER' BOMB

President Eisenhower, Defense Secretary Charles E. Wilson, and AEC Chairman Lewis L. Strauss subsequently reported development of "cleaner" H-bombs.

FIGURE 8-5 NEWSPAPER ARTICLE, WASHINGTON NEWS, "H-TEST A CLOSE SQUEAK FOR MARSHALL ISLANDS"

5-12-57

64 Islanders Dusted By Ashes -- Alive

WASHINGTON (UP)—Sixty-four Marshall Islanders dusted with "Bikini ashes" from the big H-bomb test of March 1, 1954, are alive today only because they lived on the south side of their native atoll.

If they had lived some 40 miles to the north, all would now be dead. As it was, all suffered radiation injury but have now recovered—as far as detectable effects are concerned.

This information about the so-called "Bravo Shot" of the 1954 H-bomb tests in the Pacific was disclosed for the first time in testimony released today by a House Appropriations Subcommittee.

The revealing testimony was by Dr. Frank H. Shelton, technical director of the armed forces special weapons project, which plays an important role in development and testing of atomic arms.

Although some of the facts reported by Shelton had been known to reporters, they never had been publicly stated before by any official.

Bravo was the extremely "dirty" bomb that alerted the world to the menace of radioactive fallout. In all, 239 Marshall Islanders living on atols east and southeast of Bikini suffered radiation injury.

The worst afflicted were 64 inhabitants of Rongelap, the nearest atoll to Bikini. They lived only on the southern side of their atoll, which is roughly 40 miles in its north-south dimension.

According to Shelton, if the natives had lived on the north side of their atoll, where the fallout was more intense, "all would have died."

FIGURE 8-6 NEWSPAPER ARTICLE, WASHINGTON NEWS, "64 ISLANDERS DUSTED BY ASHES - ALIVE"

Not All People Would Be Doomed By Atom Fallout

WASHINGTON (UPI) — A defense expert sought today to quiet fears that worldwide fallout from large-scale nuclear war would doom all peoples.

"Even for a very large-scale war," he said, "the worldwide hazard to the countries not attacked would not be very important in terms of their survival."

The expert was Dr. Frank Shelton, 34-year-old technical director of the Defense Department's atomic support agency. He testified before a congressional atomic energy subcomittee at hearings intended to show the world what its fate would be if East and West should trade heavy nuclear blows.

Shelton made it clear that noncombatant countries close enough to the target nations to be caught in short-term local fallout might suffer greatly. But the straospheric fallout, which hangs in the high atmosphere for periods up to several years, would not threaten the survial of everybody, he said.

Shelton detailed the terrific damage that would be done to target areas by heat, blast, prompt radiation, and local fallout. His figures have been published before. They add up to fantastic disaster.

But Shelton appeared unimpressed by the worldwide menace of long-lasting nuclear fallout such as would be generated by a war with H-bombs. He said 1,000 megatons would bring the level of strongium-90, the cancer-causing principal villain of stratospheric fallout, up to about the maximum permissible level in the northern hemisphere.

The genetic dose, inflicted upon the cells of heredity, would not be much greater than the existing natural background dose, he said.

Sen. Clinton P. Anderson (D-N.M.), chairman of the full joint atomic committee, took sharp issue with Shelton about the worldwide hazard until the witness explained he was not referring to local fallout. This consists of radioactive particles which come down in a matter of hours, days, or weeks after an explosion.

Anderson asked Shelton if he was telling countries like France and Belgium "not to worry" if the United States and Russia traded hydrogen punches.

Shelton made it clear that if they got caught in local fallout patterns they would be in trouble.

FIGURE 8-10. "NOT ALL PEOPLE WOULD BE DOOMED BY ATOM FALLOUT," CONGRESSIONAL TESTIMONY BY DR. FRANK SHELTON, 7 JUNE 1957

the Oval Office of the White House for 24 June 1957. Members of the Presidential briefing team that Strauss had assembled were all from the University of California Radiation Laboratory (UCRL, the second nuclear weapons design laboratory): Ernest Lawrence, Mark Mills, and Edward Teller. It was probably Mark Mills' idea to brief the President, following the sharp exchange between Senator Anderson and General Starbird at the recently concluded "fallout" hearings. Conspicuous by their absence from the Presidential briefing were the Los Alamos weapon designers. After all, it was the "clean" NAVAJO shot on Operation REDWING (1956), designed by LASL, that established the state-of-the-art in reduced fission weapon designs.

"We now believe that we know how to make virtually clean weapons, not only in the megaton range, but all the way down to small kiloton weapons," Lawrence told the President. *"It will take considerable time and effort to do this, but if we were to fail to develop such weapons and to convert our existing weapons, then--if the 'dirty' weapons should be used in war--our failure could truly be called a crime against humanity."*

Teller added to the argument:

"We have started some thinking on how to make atomic explosions for peaceful purposes. Clean thermonuclear weapons could be detonated in deep caverns to produce steam, to break up taconite ore, to release oil from oil strata, to cut through large Earth barriers and modify the flow of rivers, and perhaps even to modify the weather on a broad basis through changing the dust content of the air."

Teller's "peaceful purposes" theme, at the Presidential briefing, had been given a major boost by the inclusion of the "RAINIER shot" as a fully contained underground experiment into the 1957 Operation PLUMBBOB list of approved shots. Ed Teller, UCRL, and Dave Griggs, of the Rand Corporation, had begun in early 1956 a

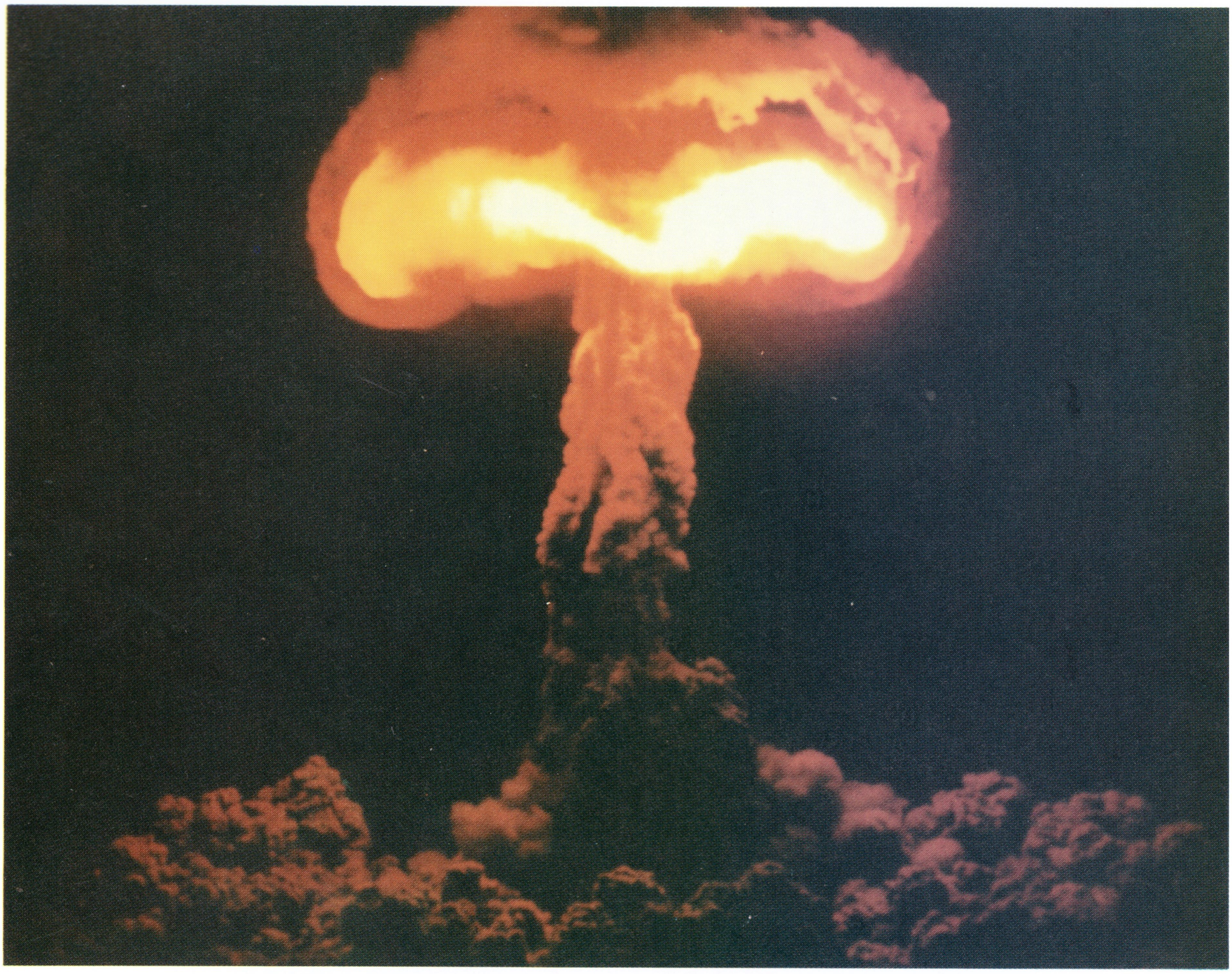


FIGURE 8-19. PLUMBBOB - HOOD SHOT, 5 JULY 1957, 1500', BALLOON, 74 KT (LARGEST)

FIGURE 8-20. PLUMBBOB - DIABLO SHOT, 15 JULY 1957, 500', TOWER, 17 KT

FIGURE 8-21. PLUMBBOB - STOKES SHOT, 7 AUGUST 1957, 1500', BALLOON, 19 KT

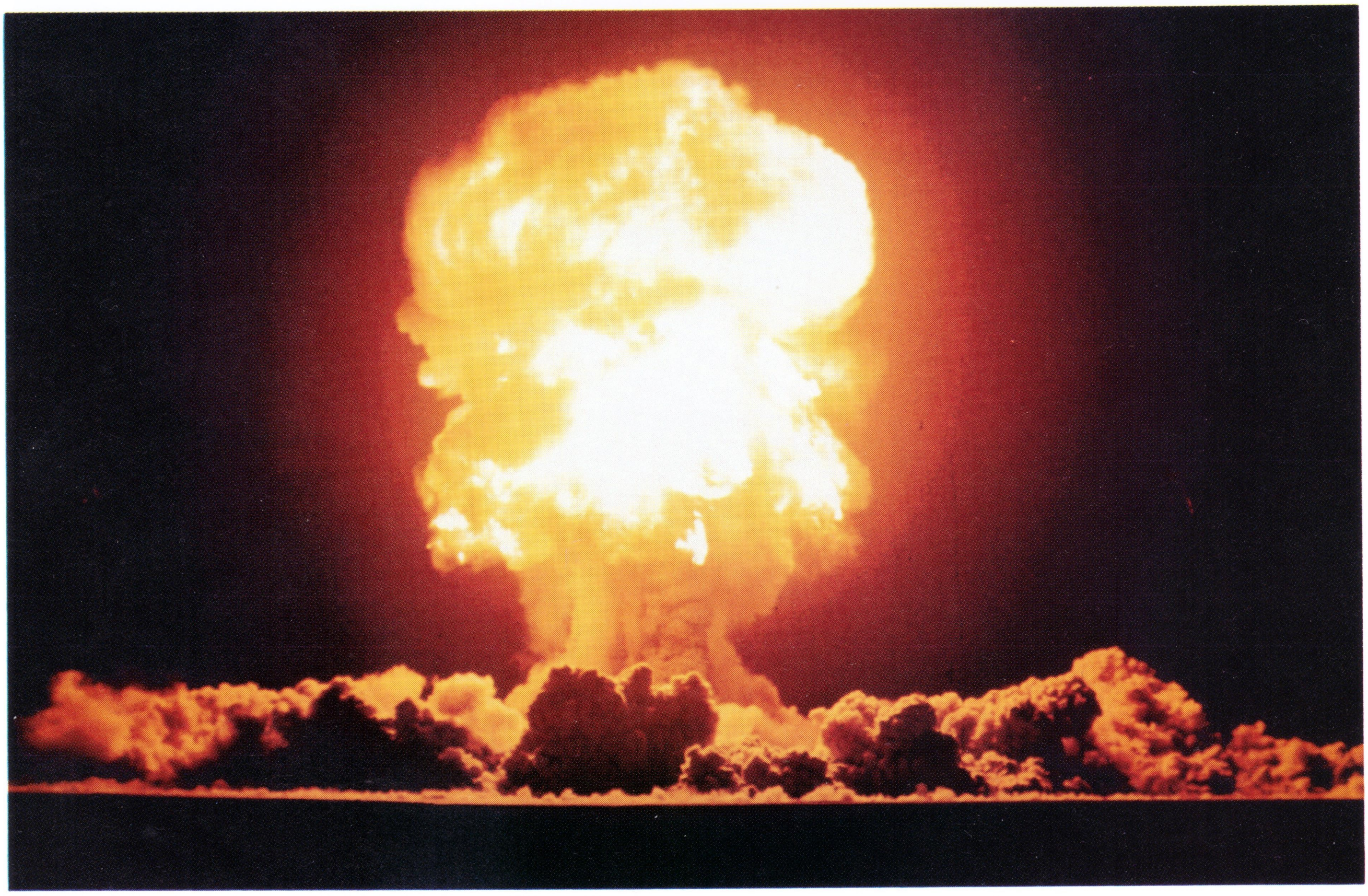


FIGURE 8-22. PLUMBBOB - FIZEAU SHOT, 14 SEPTEMBER 1957, 500', TOWER, 11 KT

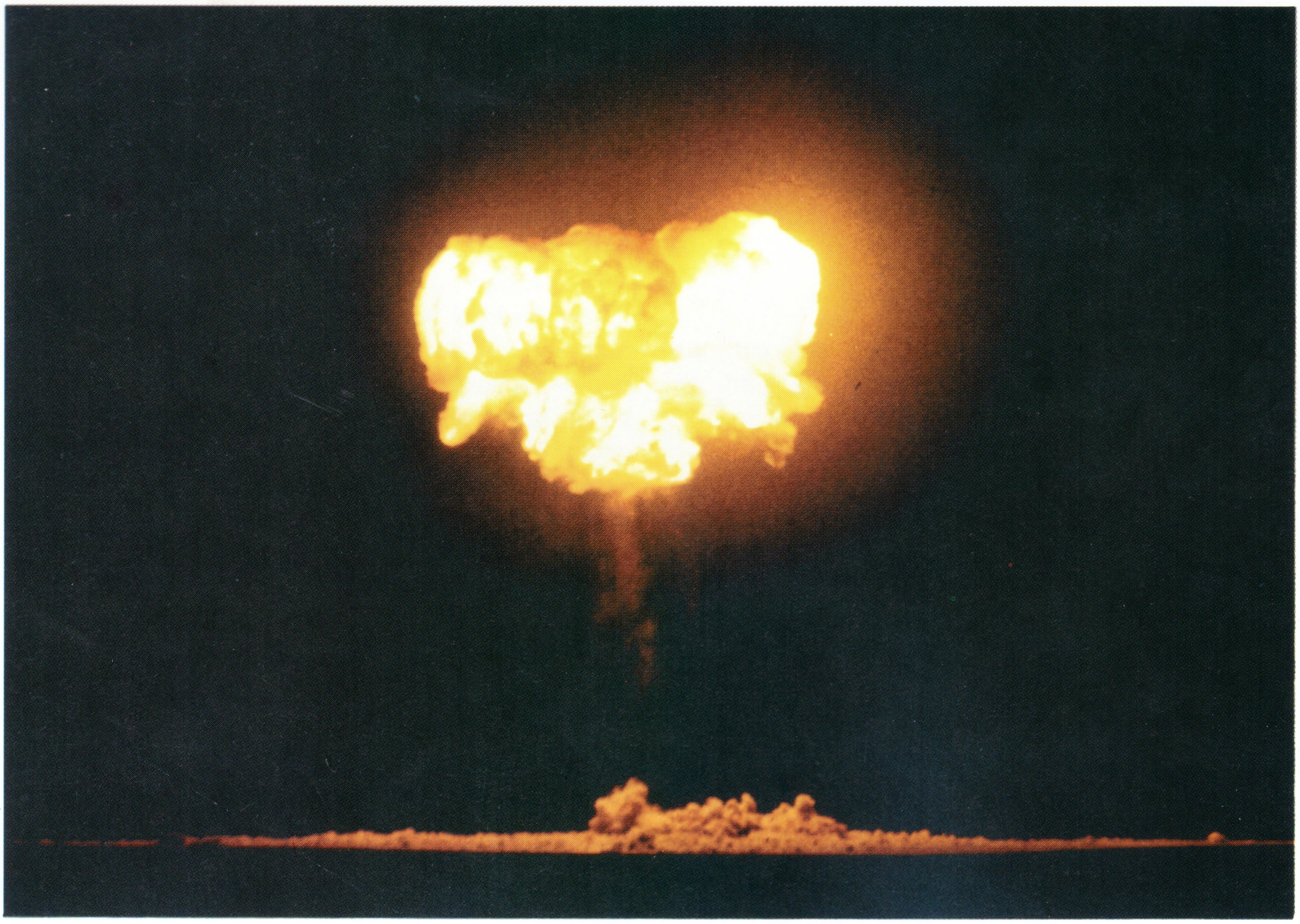


FIGURE 8-23. PLUMBBOB - CHARLESTON SHOT, 28 SEPTEMBER 1957, 1500', BALLOON, 12 KT

T-1 (M-101)
Weight, lb:
Loaded: 37,850
Payload: 2,650
Range, miles: 500
Diameter, in.: 66
Length, ft.: 62

T-2 (M-103)
Weight, lb:
Loaded: 110,000
Payload: 2,450
Range, miles: 1,850
Diameter, in.: 100
Length, ft.: about 66

In 1957 the T-1 missile was operational, but was also being used as a test vehicle for more advanced Soviet missiles. The T-1's liquid propellant engines were used as upper stage units in the T-3 ICBM.

The Soviet T-2 (M-103) surface to surface missile was an outgrowth of the German A-10 design, which never reached the production phase in Germany before the end of World War II. The T-2 was an IRBM, two stage operational missile deployed throughout the Soviet Union in 1957. With a 1,850 mile range the Russians put Western Europe and North Africa at risk with the nuclear warhead tipped T-2 missile.

Static testing of the T-2 missile began in 1951, and full-scale firings were observed in 1955. Using an inertial guidance system, operational testing of the T-2 continued at about the rate of five launches per month during 1956 and 1957.

By 1957 the Soviet T-3 (M-104) missile, with its 5,000 mile three stage system, was operational and in large scale production. The first stage of the T-3 was powered by a large 480 thousand pound thrust rocket motor, the second stage by a T-2 motor, and the third stage by a T-1 propulsion unit.

T-3 (M-104)
Weight, lb.:
Loaded: about 175,000
Payload: 2,200
Range, miles: 5,000
Diameter, in.: 190
Length, ft.: about 90

With a thermonuclear warhead payload, the ICBM T-3 was inertially guided and had an accuracy of about 10 miles to target.

With characteristics similar to the T-3, the T-3A was somewhat larger and had a range of more than 7,000 miles. The new first-stage motor had a thrust of more than one-half million pounds. Equipped with a new radio inertial guidance system, the missile was fin-stabilized at about mid-way along its length.

T-3A
Weight, lb.:
Loaded: about 175,000
Payload: about 1,100
Range, miles: over 7,000
Diameter, in.: 144
Length, ft.: 92

A T-3A missile system was most likely used to launch Sputnik 1 and the other Soviet satellites and space probes, beginning in late 1957.

United States Of America's Missiles

The U.S. Air Force brought to fruition the Atlas ICBM with its announcement in November 1957 (a month after Sputnik 1) that the Strategic Air Command (SAC) had an initial operational capability (IOC). The First Missile Division was transferred from the Air Research and Development Center (ARDC, with headquarters in Baltimore, Maryland) to SAC in January 1958 for training of handling and launching crews at Vandenburg Air Force Base, California. Additionally, the 1st Missile Division would also operate the megaton range thermonuclear warhead tipped Atlas ICBMs from its headquarters at Warren Air Force Base, Wyoming. (11)

Atlas ICBM

Development of the Atlas ICBM missiles began in 1945 when the Air Technical Training Command solicited proposals from several U.S. aerospace companies to study potential problems that might be encountered in the development of a long-range ballistic missile system. Consolidated Vultee Aircraft (later named Convair) received, in April 1947, a study contract that evolved into a construction contract that produced three fairly successful missile flights in 1948, using Reaction Motors, Inc.'s rocket engines having four chamber liquid swivel-type propulsion motors. Upon completion, the Air Force contract with Convair was allowed to run out in 1948, without follow-on effort.

The Strategic Missile Evaluation Committee, composed of prominent aerospace people with outstanding credentials, reviewed in 1953 the state-of-the-art in ballistic missile technology, coupled with recent large yield thermonuclear weapons development. (IVY KING, for example, was a deliverable one-half megaton fission weapon exploded in 1952 at the Pacific Proving Grounds.) The Committee concluded in early 1954 that a new ICBM-thermonuclear weapon study should be pursued. The Atlas ICBM missile program sprang to life in 1954, when Operation CASTLE proof tested new lightweight, high yield thermonuclear weapons. The Space Technology Laboratories (STL), Inc., under the management of Si Ramo and Dean Wooldridge, was given overall weapons systems management authority and provided general technical direction and systems engineering support for the Atlas program.

It was at this point that my friend Ed Doll left the nuclear weapons testing programs and joined is old class mates, Si Ramo and Dean Wooldridge, in mid-1955. STL was the Systems Engineering and Technical Assistance (SETA) contractor to the Air Force Western Development Division (WDD) under the capable leadership of Major General Bernard (Bernie) Schriever. (See Chapter 7 on Nuclear Test Personnel In Transition.) (K)

(K) Edward B. Doll, CalTech, BS 1934 Applied Physics; MS, 1935, EE; Ph.D., 1938, EE.
Simon Ramo, CalTech, Ph.D., 1936, EE.
Dean Wooldridge, CalTech, Ph.D., 1936 Ph.D.

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14. "Journal of Geophysical Research," Vol. 64, No. 8, August 1959, The Scientific Publication of the American Geophysical Union.

15. Private correspondence William G. Penney, 26 February 1989, "I looked in our visitors' book and found that you, Curt Lampson and Greg Hartmann, visited us on 10 September 1957."

16. Communication from LTG Austin W. Betts (Retired), 21 April 1992, "Roy Johnson was the first Director of ARPA who lasted one year and quit in frustration. Herb York was his top scientist. I took over as a BG, with George Sutton as my top scientist. He is now with LLNL. Also, I became a MG as DMA in AEC."

CALENDAR

1956

*6 Nov Eisenhower reelected President, defeating Governor Stevenson.

*6 Nov *At the request of Dr. W.F. Libby, Commissioner AEC, Dr. Shelton met with him to discuss information available within the Department of Defense (DOD) concerning fallout from REDWING (May-July 1956) events. It was agreed that an effort would be made (by Dr. Shelton) to compile the DOD fallout data obtained on Operation REDWING, in summary form, for his (Libby's) use.*

**16 Nov *Meeting of the Coordinating Committee on Equipment and Supply, Office of Secretary of Defense, vulnerability of floating top petroleum tanks to nuclear detonation blast/thermal - attended by Dr. Shelton.*

17 Nov Soviet Union detonates small nuclear device in S-W Siberia.

19 Nov *Technical Director AFSWP presented to the AFSWP/AEC Nuclear Safety Working Group the proposed AFSWP experimental program for one-point detonations of Pu bearing weapons, at a meeting hosted in Sandia Corporation.*

26 Nov *Dr. Shelton with Rear Admiral Horacio Rivero (Deputy Chief AFSWP) and Colonel Dent L. Lay (USAF, Chief Weapons Effects Division, AFSWP) visited Dr. W.F. Libby (Commissioner AEC) and presented AFSWP comments on Dr. Libby's proposed chapter on "World-Wide Fallout" for inclusion in the forthcoming edition of "The Effects of Nuclear Weapons." Dr. Shelton recommended that the proposed chapter not be included, but AFSWP would work closely with him as the DOD High Altitude Sampling Program (HASP) obtained definitive data on world-wide fallout. For security reasons, we were unable to inform him of the developing U-2 high altitude sampling program. Willard Libby, reluctantly, accepted the recommendation.*

27 Nov *Technical Director AFSWP presented to the Thermal Radiation Panel (in Headquarters AFSWP) results of the High Altitude experiment on TEAPOT (1955) as preliminary thoughts on preparations for ultra-high altitude missile nuclear detonations in 1958.*

1957

10 Jan *At the request of Dr. W.F. Libby, Commissioner AEC, Dr. Shelton met with him to discuss progress on obtaining better fallout radiation contours for Operation REDWING shots. Dr. Shelton received a pre-dated copy of "Fireball Chemistry Project," sponsored by Libby which considered ways and means of reducing the accessibility of radio-strontium in the fallout as a result of tests of high yield. Dr. Shelton, subsequently participated in several meetings with representatives of LASL, UCRL, Princeton University, Air Force Research Center, and AEC on this subject.*

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* Indented dates are a chronology of atomic bomb developments, testing,and related political matters.

** Shelton = Technical Director AFSWP checked recently the dates with existing classified "Historian's Records" in the Department of Defense (DNA).

HARDTACK CRATERING:

computer numerical simulation calculation (D.E. Burton, et al, Lawrence Livermore Radiation Laboratory, August 1984) using a multiphase constitutive model that accounts for pore pressure and porous flow of fractured Eniwetok coral showed that the size and shape of the KOA crater could be accounted for by subsidence and liquification phenomena. The model produced a crater having 95 percent of the measured volume of the KOA crater. (Figure 9-11, Pacific Craters.)

A decade ago, and earlier, the few attempts to numerically simulate high yield, surface burst nuclear explosions did not produce crater calculations that were consistent with the observed size and shape of the Pacific Proving Ground craters. Corresponding calculations for reasonable stiff geologic media (such as that representative of the Soviet Union missile silo sites) indicated crater ejecta volumes that were smaller than the Pacific Proving Ground empirical data by factors of 40 to 100. For example, in 1975 (J.C. Trulio of Applied Theory Inc.) the calculations of a 1-MT surface burst in stiff geology gave an ejecta crater of about 1,000 - 1,225 feet radius, and much deeper than the 1.4-MT KOA crater (2,160 feet radius, 170 feet depth) in coral reef material.

At that time, Air Force Strategic Air Command (SAC) and the Joint Strategic Target Planning Staff (JSTPS) discounted such calculations in favor of using the empirical evidence of the Pacific Proving Ground craters for Soviet Union strategic targets, using a kill criterion of less than a crater radius. Even at the late date of 1985, the "Capabilities of Nuclear Weapons," a classified document (Effects Manual-1) and the "Air Force Manual for Design and Analysis of Hardened Structures," are widely used references that illustrate the dependence on using Pacific Proving Ground empirical crater dimensions. (8)

A summary of empirical crater dimensions from detonations at Eniwetok and Bikini Atolls and the Nevada Test Site is given in Table 9-2. A relative simple criterion for assessing the shape of a crater is the ratio of its radius (R) to depth (D), or R/D, which is always about two for most ejecta craters produced by high explosives, nuclear weapons and meteor impacts on the moon and the planet Mercury a notable exception being the large-yield Pacific craters.

CACTUS Event And Its Crater

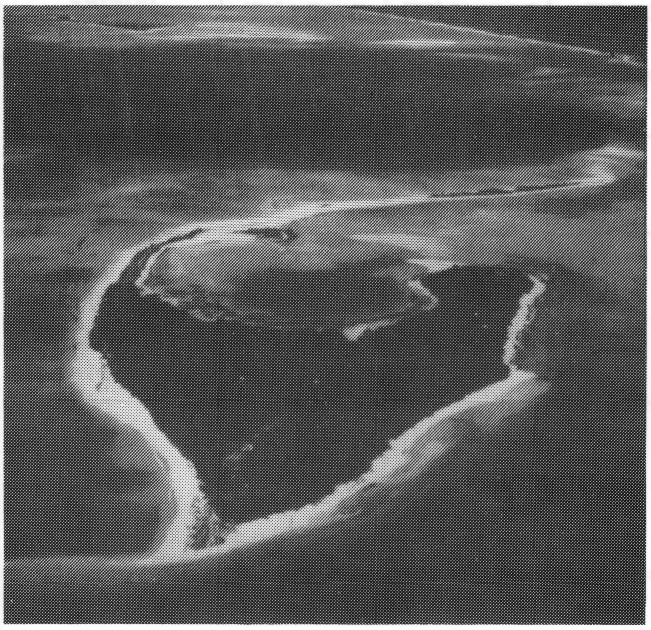
Colonel "Ted" Parsons (USAF), Armed Forces Special Weapons Project Deputy for Department of Defense Programs on the Joint Task Force-Seven staff, piloted the small, single engine liaison aircraft as we flew from Eniwetok (Elmer) Island to Runit (Yvonne) Island for a walking tour of the CACTUS shot area on 18 April 1958--a little over two weeks before it was scheduled to be detonated. As we approached Runit Island, the large Cactus ground zero shot cab structure and the radiating diagnostic line-of-sight pipes and tunnels were clearly evident. (Figure 9-12, CACTUS Shot Area.)

I mentioned to Ted that the old LACROSSE crater (REDWING-1956) looked about the same as it did when we flew up a few hours after it was created. After landing on Runit, we walked to the blast line, and I took careful note of the "Q-gauges" that had been mounted to measure the blast dynamic pressures on CACTUS, which should have been nearly "ideal" values for a surface burst. The large drum gauges to measure air-ground interface pressures near the crater edge had been installed about a month previously. (Figure 9-13, picture taken the next day upon request; Figure 9-13a, Q-Gauges; Figure 9-13b, Drum Gauges .)

The CACTUS ground zero building was constructed of steel frame, 33 by 34 by 30 feet high, with a black corrugated protective metal roof and sides and a 6-inch concrete slab floor. The nuclear device was mounted 3 feet above the floor with massive asymmetric sand-filled concrete baffles around the weapon that were 13 feet high. The construction weights for the CACTUS GZ station, excluding the foundation, were: concrete, 200,000 pounds; coral sand, 55,000 pounds; and structural & rebar steel, 87,000 pounds (9: see Figure 9-8.)

The CACTUS device was detonated 596 feet southwest of the LACROSSE ground zero at 0615 hours on 6 May 1958 with a yield of 18 KT. The CACTUS crater dimensions were: radius = 173 feet; depth at GZ = 34.5 feet, and maximum depth = 37.2 feet; crater lip height = 8 to 14 feet (see Table 9-2). (Figure 9-14, CACTUS Crater.)

There was an effort in 1979-1980 to clean up the residual radioactive materials present on



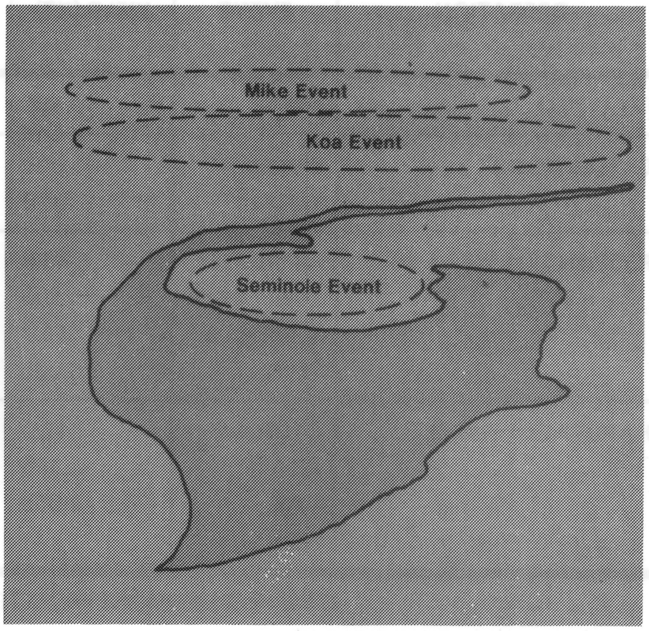


FIGURE 9-11a. PACIFIC CRATERS IN THE MARSHALL ISLANDS, CRATERS PRODUCED BY SOME U.S. NUCLEAR TESTS AT THE PACIFIC PROVING GROUND IN THE MARSHALL ISLANDS

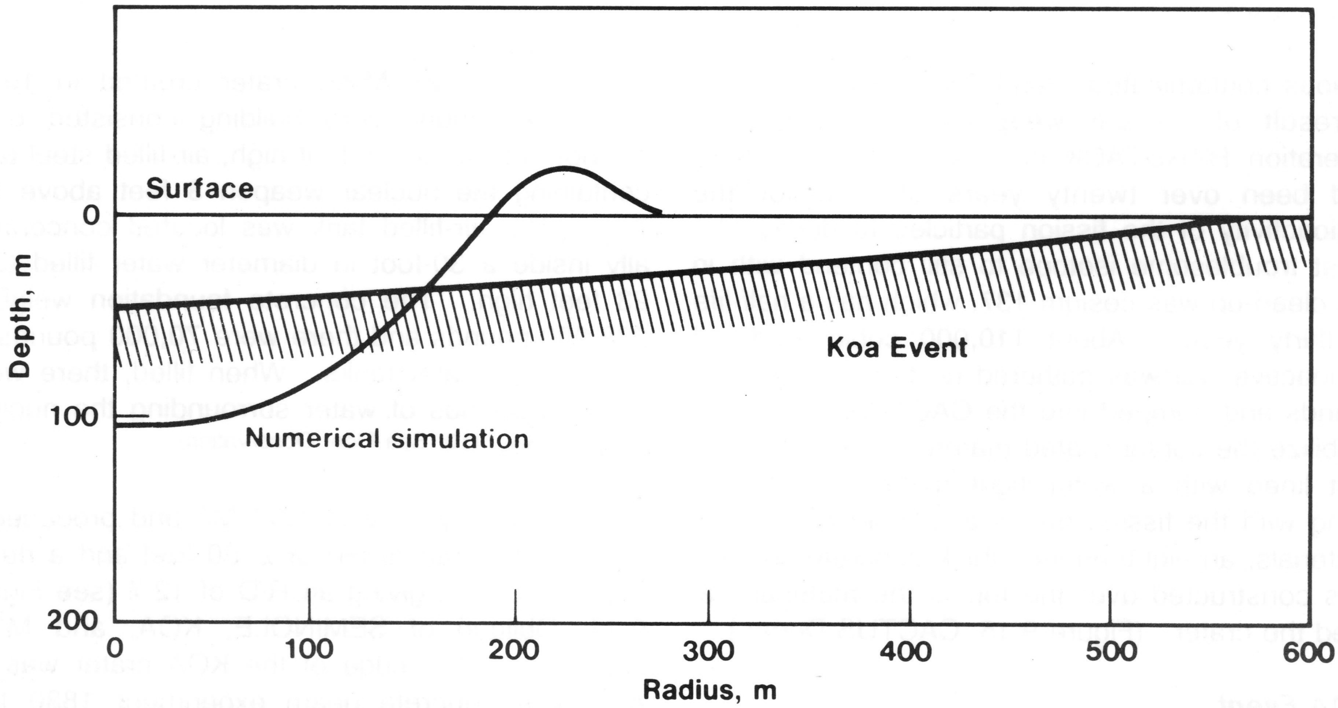


FIGURE 9-11b. PACIFIC CRATER CALCULATIONS, PROFILE OF THE PACIFIC PROVING GROUND CRATER PRODUCED BY THE KOA EVENT, CONTRASTED WITH THE CRATER RESULTING FROM A TYPICAL NUMERICAL SIMULATION

TABLE 9-2. CRATER DIMENSIONS FROM DETONATIONS AT ENIWETOK AND BIKINI ATOLLS AND NEVADA TEST SITE

OPERATION	EVENT	YIELD (KT)	HOB (FT)	RADIUS (FT)	DEPTH (FT)	RADIUS / DEPTH
CRATER DIMENSIONS FROM TEST EVENTS AT ENIWETOK AND BIKINI ATOLLS						
IVY (1952)	MIKE	10,400	10.0	2910	187.0	15.6
CASTLE (1954)	BRAVO	15,000	7.0	3255	250.0	13.0
	KOON	110	9.6	495	40.0	12.4
REDWING (1956)	LACROSSE	40.0	9.6	200	55.5	3.6
	ZUNI	3,500	10.0	1165	113.0	10.3
	SEMINOLE	13.7	7.0	324	32.2	10.1
	TEWA	5,000	10.0	1915	133.0	14.1
HARDTACK I (1958)	CACTUS	18.0	3.0	173	37.2	4.65
	KOA	1,370	2.7	2160	170.0	12.70
	OAK	8,900	5.8	2870	204.0	14.70
	FIG		1.5	18	9.7	1.86
CRATER DIMENSIONS FROM TEST EVENTS AT NEVADA TEST SITE						
BUSTER JANGLE (1951)	SUGAR	1.2	+ 3.5	45	21	2.10
	UNCLE	1.2	-17	130	53	2.45
TEAPOT (1955)	ESS	1.0	-67	146	96	1.6
NOUGAT (1962)	SEDAN	104	-635	640	320-	2.0

various contaminated islands in Eniwetok Atoll as a result of nuclear weapons testing through Operation HARDTACK in 1958. Although there had been over twenty years of time for the radioactivity of the fission particles to decay, the most troublesome isotope to still contend with in the clean-up was cesium-137, which has a half-life of thirty years. About 110,000 cubic yards of radioactive soil was gathered up from the various islands and dumped into the CACTUS crater. To stabilize the contaminated material, the crater was first lined with a water tight material; and after filling with the fission debris and other radioactive materials, an eighteen-inch thick concrete "dome" was constructed over the top of the material that filled the crater. (Figure 9-15, CACTUS Dome.)

KOA Event

The KOA nuclear device was detonated 13 May 1958 in a water tank at the west end of Gene Island, at the north end of Eniwetok Atoll, near the old IVY MIKE crater created in 1952. The KOA ground zero building consisted of a 10-foot in diameter, 8 foot high, air-filled steel tank containing the nuclear weapon 3 feet above the floor. The air-filled tank was located concentrically inside a 30-foot in diameter water filled tank 23 feet high. The concrete foundation weighed 278,000 pounds and there were 70,000 pounds of steel in the water tanks. When filled, there were 870,000 pounds of water surrounding the nuclear detonation. (10: Sea-Floor Observation)

The KOA yield was 1.37 MT and produced a crater with a radius (R) of 2160 feet and a depth (D) of 170 feet, giving an R/D of 12.7 (see Figure 9-11, Oblique of SEMINOLE, KOA, and MIKE craters). At the edge of the KOA crater was an Air Force concrete beam experiment 1830 feet from ground zero inside of what appeared to be the crater radius (see Figure 9-16, pre-shot beam). After the shot, the top of the concrete beam experiment was 6.5 feet lower than pre-shot

FIGURE 9-12a. HARDTACK, SHOT CACTUS, ENIWETOK, SITE YVONNE, 18 KT SURFACE, VIEWING S.

FIGURE 9-12b. HARDTACK, SHOT CACTUS, ENIWETOK, SITE YVONNE, 18 KT SURFACE, VIEWING N.

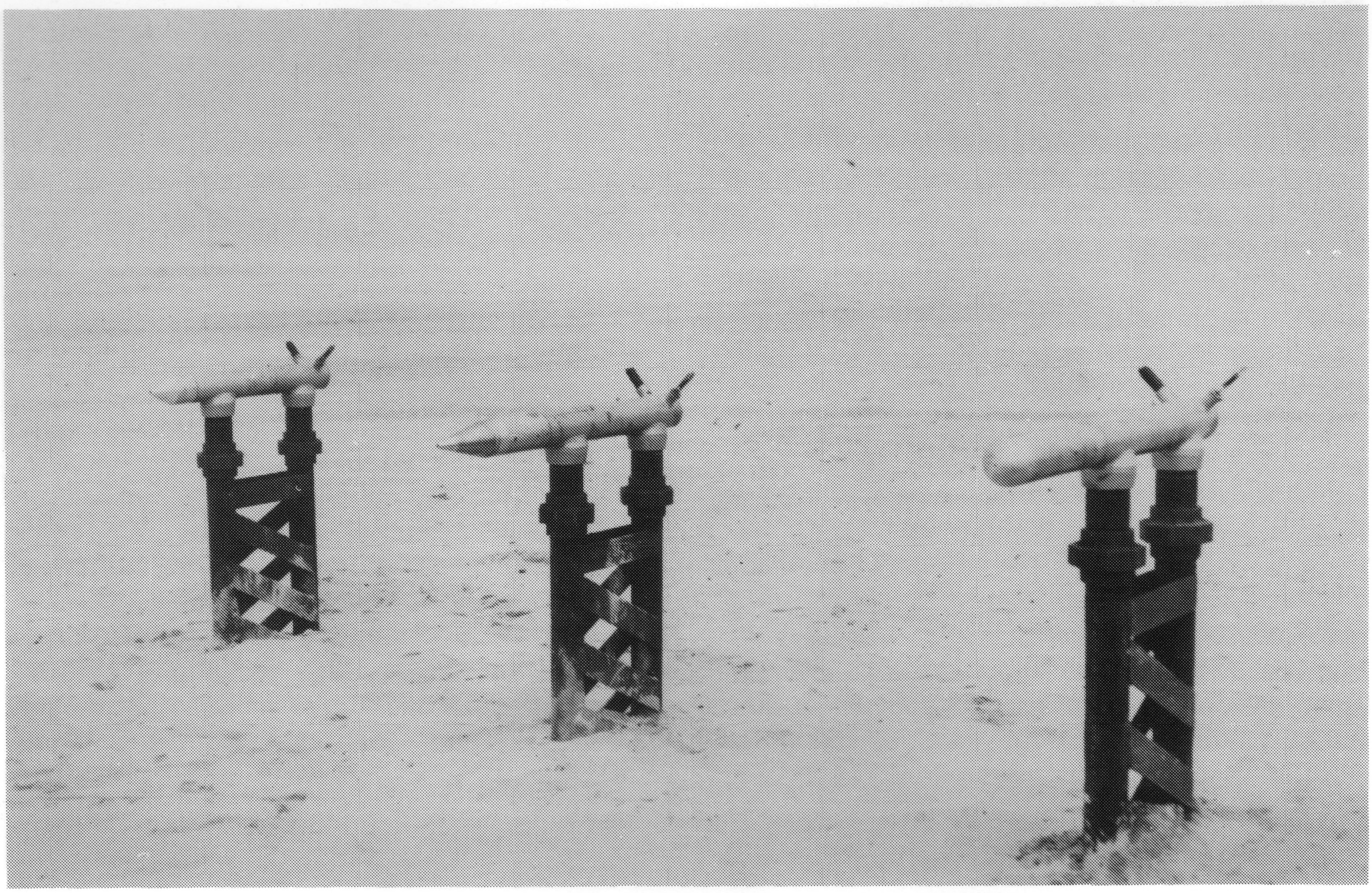


FIGURE 9-13a. HARDTACK, SHOT CACTUS, ENIWETOK ATOLL, Q-GAUGES, TAKEN 19 APRIL 1958

FIGURE 9-13b. HARDTACK, SHOT CACTUS, LOWERING DRUM GAUGES, TAKEN 28 MARCH 1958

FIGURE 9-14a. HARDTACK, SHOT CACTUS, SURFACE BURST, H + 3

FIGURE 9-14b. HARDTACK, SHOT CACTUS, ENIWETOK ATOLL, PHOTO: D + 3, VIEWING S., (LACROSSE CRATER ON LEFT)

FIGURE 9-15. CACTUS DOME COVERS MOST NUCLEAR MATERIAL AT ENIWETOK ATOLL

and the coral reef material around the concrete was compressed an additional 3 feet (see Figure 9-16). This type of data adds credence to the theory that the shallow saucer shapes of the Pacific craters are not due to ejecta cratering but due to compression and liquification of the coral, causing it to flow back toward ground zero under the high pressure air blast (greater than 1,000 psi) and long duration of the blast wave. (11: Geologic and Geophysical.)

OAK Event

OAK event, 8.9 megatons (MT), was detonated on a barge in shallow water (13 feet) on the west reef of Eniwetok Atoll (see Figure 9-4, Map). The detonation occurred at 0730 hours on 29 June 1958. The axis of the nuclear device was horizontal, three feet above the barge deck, and the barge deck was about 5.6 feet above the water line at shot time. The barge was composed of 446,000 pounds of steel and there was no sand ballast (usually equal to the barge weight) to provide a shallow draft for the barge. (See Table 9-2 for OAK crater dimensions.)

AEC Commissioner Bill Libby was the only technical member on the Commission during the planning and execution of Operation HARDTACK. Dr. Libby put a lot of thought and effort into reducing the effects of worldwide fallout, especially from the large multi-megaton thermonuclear events scheduled for the 1958 Pacific series. I had reviewed an early copy of his manuscript on "Fireball Chemistry" that explored the possibility of ballasting each of the barge shots with about 225 tons of silica sand, instead of the 225 ton of coral sand that was usually employed. The theory was that during the early fireball phase of the explosion the strontium-90 would be chemically combined at the very high temperatures with the silica sand to form a water insoluble strontium silicate. Insoluble strontium-90 would thus be eliminated from the food chain, especially

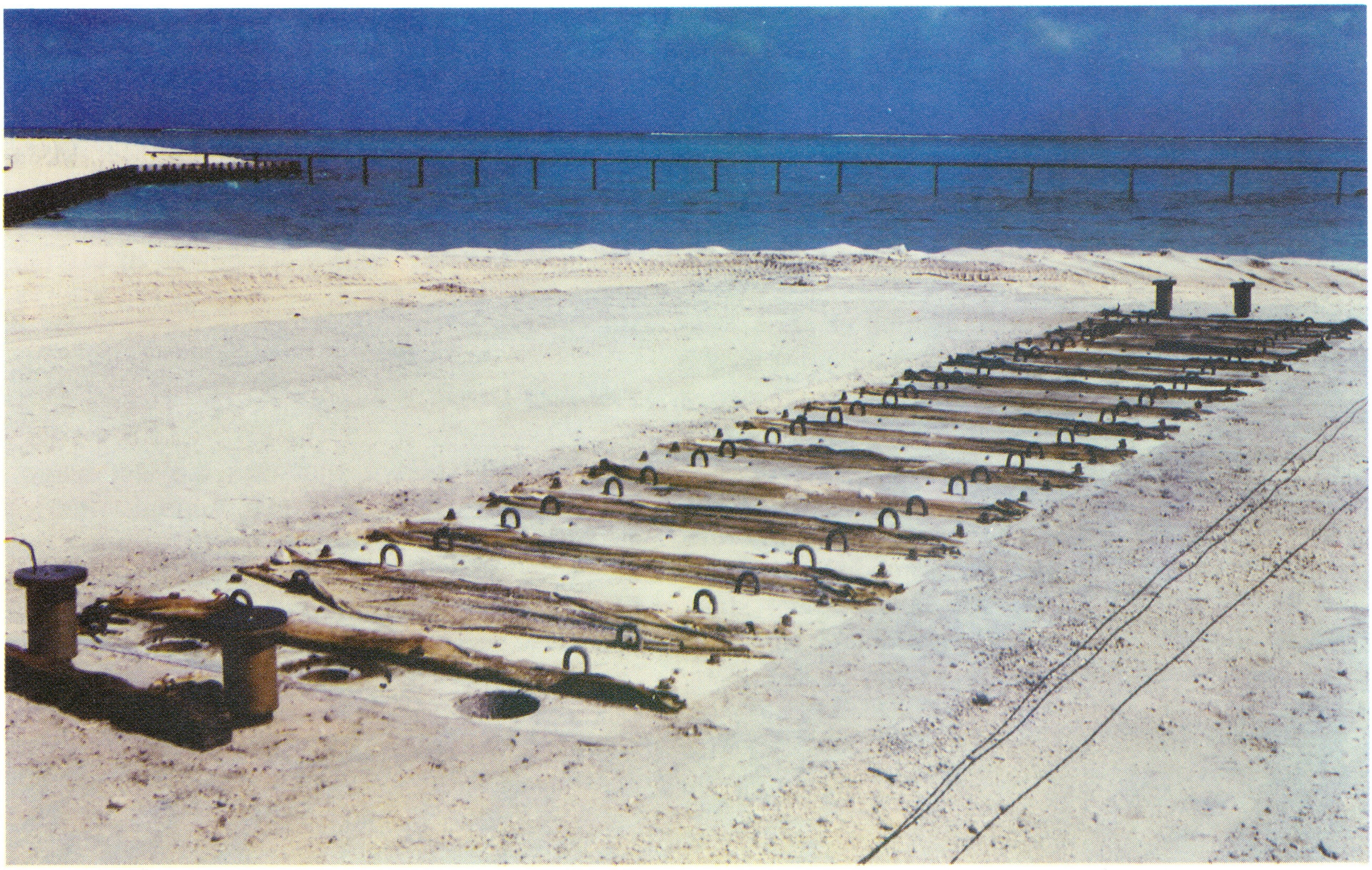


FIGURE 9-16b. HARDTACK, SHOT KOA, ENIWETOK ATOLL, SITE GENE, 13 MAY 1958, 1.37 MT, PHOTO: D + 8, 21 MAY 1958, POST-SHOT CONCRETE BEAM EXP, 6.5 FT. LOWER THAN PRE-SHOT AT 1,830 FT., PO = 1,130 PSI, RA = 2,160 FT.

the milk chain for children during their bone growth phase. The barge shots that incorporated silica sand as ballast on Operation HARDTACK are indicated in Table 9-2. Although the OAK barge event had an impressive yield of 8.9 MT, it was not the largest shot fired on Operation HARDTACK.

Incorporating thousands of tons of silica sand into the barge shots meant transporting it to the Pacific Proving Grounds from Hawaii. During a number of discussions, both in Washington and at Eniwetok Atoll, I had the distinct impression that Bill Ogle, Scientific Director for JTF-7, was annoyed by the silica sand subject since the new procedures would impact his immediate objective of getting the AEC weapons development shots off as quickly and easily as possible. However, Bill Ogle would not have to testify, as Bill Libby and I (and many others) would before the pending 1959 hearings in radiation to be held by a special subcommittee of the Congressional Joint Committee on Atomic Energy, which had already notified us that the subject would be "Biological and Environmental Effects of Nuclear War." The YELLOWWOOD events were typical of the barge shots with Silica Sand. (Figure 9-17, YELLOWWOOD Event.)

FIG And QUINCE Events

The FIG surface shot was the last event of Operation HARDTACK I (18 August 1958) on Yvonne Island at Eniwetok Atoll, a week after ORANGE shot had occurred on Johnston Island. FIG was a late addition to the HARDTACK schedule as a cooperative effort between the AEC's University of California Radiation Laboratory

FIGURE 9-17. HARDTACK YELLOWWOOD BARGE SHOT WITH SILICA SAND BALLIST

(UCRL) and the DOD's Armed Forces Special Weapons Project (AFSWP). FIG ground zero contained 130 tons of Nevada Test Site soil that replaced coral reef material in the shape of an inverted cone that was 8 feet deep and 30 feet in diameter at the surface, with an additional six inches deep out to a radius of 35 feet. The Nevada soil was compacted to correspond to original test site conditions. (5)

Exactly the same soil preparations had taken place on the QUINCE event, but that shot had a yield that was not expected, necessitating a repeat experiment on FIG. FIG crater dimensions were exactly the same as would be expected for a Nevada detonation--18 feet radius (R) and 9.7 feet deep (D), R/D = 1.9. This experiment showed that for short duration blast waves, corresponding to the small FIG yield, the crater shape was not affected by coral pore collapse and compaction that occurred on the large yield (long duration) blast waves.

Returning to Table 9-2 (crater dimensions), the dimensions of the CACTUS crater are to be noted. The radius of CACTUS should be about 10 times the radius of FIG--which it is; and the scaled depth of CACTUS should be 97 feet, which it is not, and fails to scale by more than a factor of two. So, for nominal yield weapons, like CACTUS, the Pacific coral reef craters fail to be deep enough; and for large yields like OAK and KOA, the crater diameters are larger than expected and the depths of the craters are shallower than expected by scaling from other geologies. One should not use the empirical, large yield Pacific crater data to confidently predict that Soviet Union missile silos would be within the crater radius.

Underwater Bursts--WAHOO and UMBRELLA

The two Department of Defense sponsored HARDTACK underwater nuclear weapons effects tests could be considered a continuation of BAKER test of the Operation CROSSROADS series at Bikini in 1946 and the WIGWAM test 500 nmi off the U.S. west coast in 1955. WAHOO shot was fired at a depth of 500 feet in deep Pacific ocean water about 8,000 feet south from the nearest island on Eniwetok Atoll. UMBRELLA was detonated at a depth of 150 feet on the bottom of Eniwetok Lagoon NNE of Henry island. (Figure 9-18, UMBRELLA Underwater Burst.)

It is noted that the Soviet Union had not conducted an underwater nuclear test prior to the 1958 testing moratorium. Upon abrogating the moratorium on 1 September 1961 (thirty four months into the agreement), the Soviet Union conducted its first underwater test on 23 October 1961, having a low yield range, south of Novaya Zemlaya. Realizing during the moratorium that it had no underwater effects data, the Soviet Navy must have had grave concerns, and underwater test preparations must have begun long before the Soviets broke the moratorium to allow their test to take place about six weeks after resuming nuclear weapons testing.

TEAK--High Altitude Shot

A Redstone missile lifted off its launch pad on Johnston Island, and its powerful rocket engine drove it straight up for three minutes before its megaton-range nuclear warhead detonated at 252,000 feet (76.8 km) at 11:50 p.m. on 31 July 1958. Beginning about that time radio communications stopped throughout most of the Pacific basin. Honolulu had difficulty maintaining military and commercial air travel services. Indeed, commercial air traffic had to be suspended for many hours because of a failure of long wave communications. There was, however, no interruption of telephone line communications on Hawaii. The electromagnetic pulse (EMP) produced by the TEAK detonation was not noticed anywhere in the Pacific except for a "click" at zero time on radio receivers in the vicinity of Johnston Island. (Figures 9-19 and 9-20, Redstone Missile at JI.)

When I left the Pentagon at the end of the day on 31 July, a communication had been received from General Luedecke, Commander Joint Task Force-Seven at Johnston Island indicating that the TEAK event was "go" for late that evening. This meant that the shot would have occurred before work began in the Pentagon the next morning (11:50 p.m., 31 July, at Johnston Island is 5:50 a.m., 1 August, in Washington, D.C.). However, when I looked through the communications at about 8 a.m. on 1 August, there was nothing from General Luedecke. Being responsible to both Chairman AEC and Chairman Joint Chiefs of Staff, he would have immediately notified them that TEAK had occurred, and there would also

The New York Times March 20, 1959

Argus Weaponeer

Frank Harvey Shelton

Special to The New York Times.

WASHINGTON, March 19— For a few minutes today Dr. Frank Harvey Shelton stepped out of the anonymity that goes with his role as the Pentagon's chief atomic weaponeer. From the way the young, retiring scientist nervously wet his lips, it was apparent that he did not like the unaccustomed glare of publicity.

Man in the News

As technical director of the armed forces special weapons project, Dr. Shelton is the principal Defense Department scientist responsible for developing military requirements for atomic weapons and for conducting atomic tests.

As project director he was also responsible for the overall scientific direction of last summer's high-altitude explosions that created a sheet of radiation around the world.

It was the latter role that today drew Dr. Shelton out of his closely guarded Pentagon office to participate in a hectic news conference on the novel experiments of creating man-made radiation in space.

Associated Press

"We just don't like publicity."

Has Little to Say

Dr. Shelton had little to say about his role in what some have called "the greatest scientific experiment of all time" and when he did talk, his low mumble was virtually inaudible to reporters.

According to the person who knows him best, his wife, this quiet, shy manner is characteristic of the 34-year-old nuclear physicist.

"He talks more than he used to," she explains, "but he still doesn't talk very much. I do most of the talking, and he gets worried when I don't talk."

The quiet manner can perhaps be attributed partly to his training as a scientist more interested in research than in conversation. As one colleague described him today, "Frank is a very studious scientific fellow."

Part of the silent attitude, however, springs from the strict secrecy that surrounds his job as an atomic weaponeer.

"We have a very tough mission," he explains, of his project, "and we just don't like publicity.

Study of Cosmic Rays

Dr. Shelton was drawn into the secrecy of atomic weapons and the spectacular creation of man-made radiation in space through a study of the cosmic rays that are mysteriously created by nature.

As a graduate student at the California Institute of Technology, he specialized in research on the particles of cosmic rays. He had originally started as an engineering student but then "grew into" the field of physics.

This research in nuclear physics—he received his doctors degree for his work in 1953—lead him into the field of atomic weaponry. He was employed by the Sandia Corporation, which carries out atomic weapons developments and manufacture for the Atomic Energy Commission. Then three-and-a-half years ago he came to the Pentagon to be the technical director of the Armed Forces Special Weapons Project (abbreviated to ASWAP within the Pentagon).

Won a Scholarship

Dr. Shelton was born in 1924 at Flagstaff, Ariz., the son of a former schoolteacher and a worker on the Hoover Dam. Most of his boyhood was spent in Boulder City, Nev.

Through the winning of a scholarship Dr. Shelton was able to go to the California Institute of Technology. His college career was interrupted during World War II by a period of service with the Army, during which he obtained a commission and spent most of his time in school.

While still an undergraduate he married the former Miss Lorene Gregory of Trinidad, Colo., in 1948. They have three daughters, ranging in age from 5 to 9 years.

The type of man who brings work home from the office, Dr. Shelton has few interests or hobbies outside of his work. He occasionally dabbles in collecting stamps and coins, but as he explained today:

"I have no real hobbies. I just like my work."

FIGURE 10-5. ARGUS WEAPONEER

Quarles Sets Policy on Data but Bars Full Publication of the Project's Findings

Special to The New York Times

WASHINGTON, March 19— Some results of the Project Argus experiment are being prepared for publication by the National Academy of Sciences through "normal scientific channels."

This was announced at the Pentagon today by Donald A. Quarles, Deputy Secretary of Defense, in response to requests for details of the tests last summer in which three atomic weapons were detonated 300 miles above the earth.

This policy was confirmed by Dr. Alan T. Waterman, director of the National Science Foundation, and Dr. Detlev V. Bronk, president of the National Academy of Sciences.

They said the plans were "well advanced" for "orderly publication" in scientific journals. In addition, they said a symposium would be held at the National Academy's annual meeting here April 27, 28 and 29.

Mr. Quarles emphasized plans to keep many of the results of the test secret. He announced that he was sorry that the project was no longer a secret.

In response to a question about the publication of news of the tests in The New York Times this morning, Mr. Quarles said that this was not "playing the game" the way he liked to see it played.

Mr. Quarles, however, would not confirm that he was, in effect, accusing The Times of a security breach.

Publication Withheld

The tests were conducted last Aug. 27, Aug. 30 and Sept. 6. In publishing the account this morning, The Times explained that it had withheld publication of its information until it became evident that the Soviet Union knew of the theoretical principles involved and that a high official of the Pentagon had recommended an official announcement.

The Defense Department decided this morning to hold a news conference after numerous requests for information resulted from The Times' accounts.

But Mr. Quarles announced that if it had been up to him there would have been no disclosure. He made it clear to those who attended that The Times' publication of the news of the tests had not been officially inspired.

Mr. Quarles said that the experiments had been classified because: first, they had substantial military implications; second, "we were probing a new science here" and that more time was required to assess the results.

"The results are not the property of the scientists," he responded to a subsequent question on the same subject. "Of course the scientists publish those things which we collectively judge to be in the interest of the American people to publish."

FIGURE 10-6
QUARLES SETS POLICY

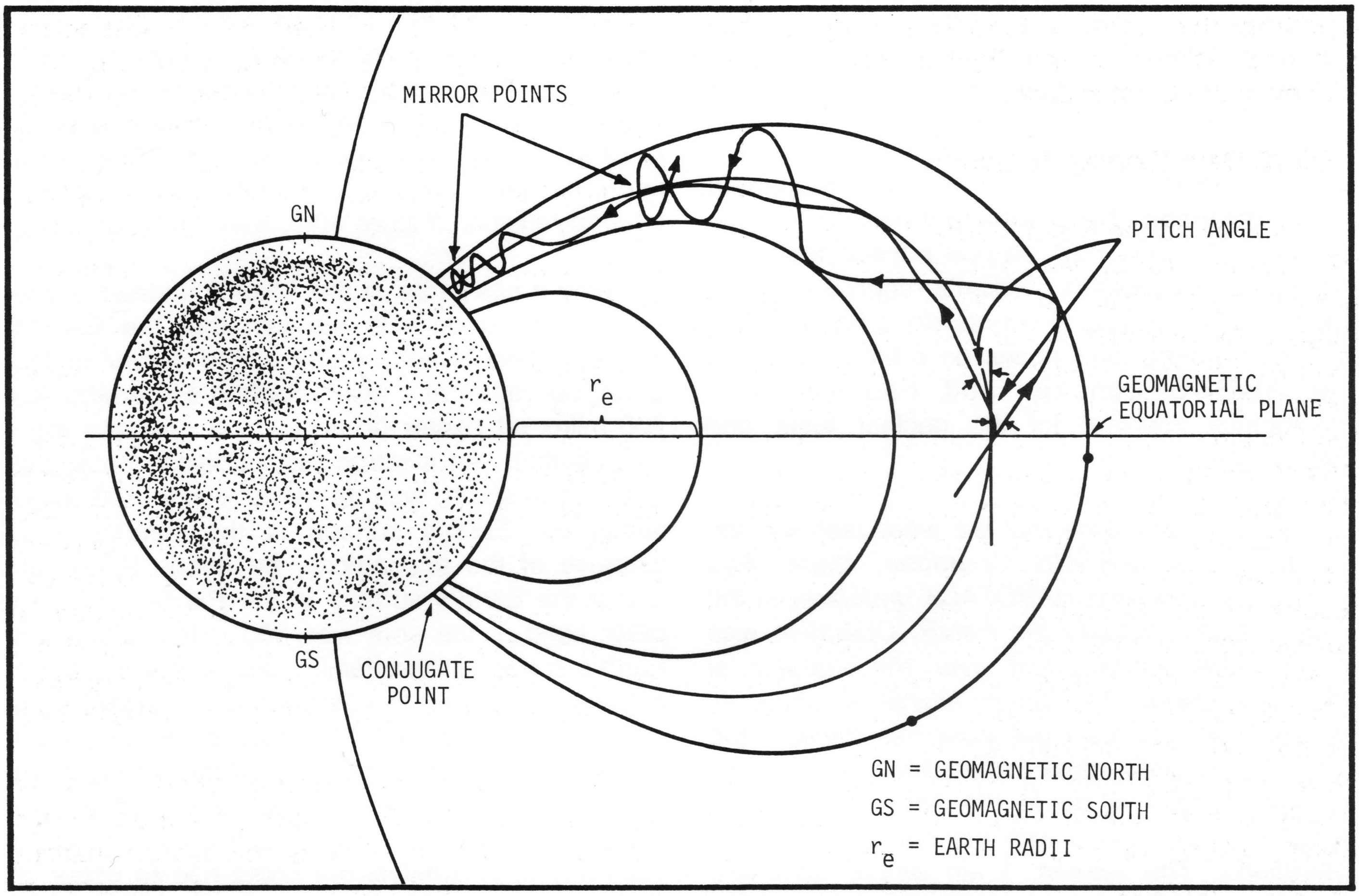


FIGURE 10-7. EARTH'S TRAPPED RADIATION DIAGRAM

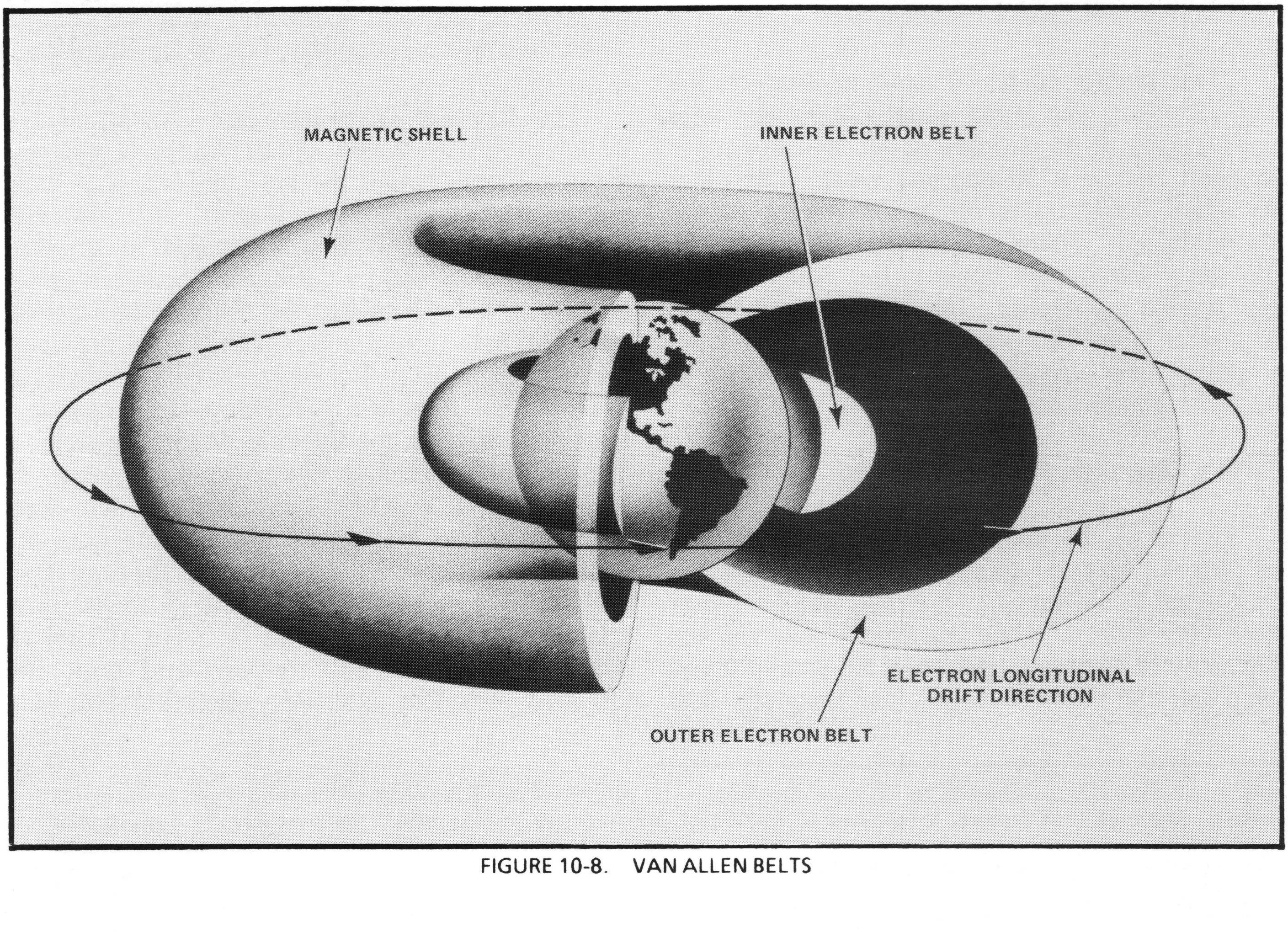


FIGURE 10-8. VAN ALLEN BELTS

THE EVENING STAR
Washington, D. C., Friday, May 8, 1959

A-Shots 30 Miles Up Not 'Clean,' Panel Says

By RICHARD FRYKLUND
Star Staff Writer

A panel of scientists told Congress today that atomic weapons tests in the upper atmosphere would not eliminate radioactive fallout.

The group of scientists, from the Atomic Energy Commission, the Department of Defense, the Public Health Service and universities, agreed 30-mile-high tests would send about 50 per cent of the potentially dangerous radioactivity back to the surface of the earth.

Small underground tests, they said, would not produce any appreciable radioactivity on the surface.

President Eisenhower wrote Soviet Premier Khrushchev on April 13 proposing that Russia and the United States agree to ban all atom bomb tests below 30 miles as a first step toward a permanent ban. The proposal was outlined the same day in Geneva by American representatives negotiating for A-test curbs with the Russians.

Today's panel and the members of the Radiation Subcommittee of the Joint Atomic Energy Committee, before which they were testifying, did not know why the American proposal specified the 30-mile limit (50 kilometers).

Dr. Willard F. Libby, Atomic Energy Commissioner, said that the only source of a 50-kilometer figure he knew of was the Geneva "experts" conference. But there was another suggestion that the experts had decided that any test over 50 kilometers could not be concealed.

Dr. Libby and other members of the panel, however, agreed that tests far out in space—a million miles or so—could not be detected. There was no way of knowing for for certain, they said, whether the Soviet Union has tried such a test.

The Pentagon on March 19 revealed a series of atomic tests last summer about 300 miles above the earth. Pentagon officials at the time said the tests produced no appreciable radioactive fallout. Apparently the tests were not noticed by the Russians.

Dr. Libby, in a prepared statement, said that five underground shots of relatively small scale—less than 20 kilotons—have shown that no radioactivity results if such tests are properly set up.

Land shots on remote Pacific islands have produced global fallout reduced by about 80 per cent, he said. Surface ocean shots apparently cut fallout by about 50 per cent. An ocean shot from a sand-filled barge may also cut fallout, he said.

A test halfway between the earth and the moon would reduce fallout to a negligible quantity, he said. Fallout from a shot 60,000 miles above the earth would be reduced to about one-tenth of 1 per cent.

But, in the case of a 30-mile-high shot, Dr. Libby and the panel agreed that 50 per cent of the radioactive material would be blasted back toward the earth and eventually would sift down to the surface.

If the particles became electrically charged, virtually all of them would be caught up by the earth's magnetic field and returned to the surface. Testing would have to be carried out many hundreds of miles from the earth to diminish fallout.

Dr. Walter Selove of the University of Pennsylvania said the American proposal had been worded to imply that 30 miles was a safe limit. The panel seemed to agree with Dr. Selove's interpretation of the American statement.

Speaking for the Department of Defense, Dr. Frank Shelton said that underground or far outer space testing would produce valuable data on explodability of the weapon, its power and the radioactivity it created, but would not produce enough information on military use of the weapon or its effect on a given type of target.

FIGURE 10-22. A-SHOTS NOT "CLEAN," PANEL SAYS

WORLDWIDE FALLOUT RADIATION DOSES--NUCLEAR TESTS

Whole body radiation doses, to people living in the northern hemisphere (about three times larger than the southern hemisphere), due to all nuclear weapons testing (U.S., U.K., and U.S.S.R.) through 1958 (prior to the testing moratorium), led to a maximum in 1959 of 30 millirem for that one year. Without further nuclear testing, after 1958, the whole body dose due to worldwide fallout, for a thirty year period (1955-1985) would have been 150 millirem; or a seventy year life time dose (1955-2025) of 200 millirem. These worldwide fallout radiation doses in the northern hemisphere, are to be compared with a natural background (cosmic ray, rocks, etc.) dose of 100 millirem per year, or 3,000 millirem for thirty years, and 7,000 millirem for seventy years. The thirty year population dose due to all nuclear weapons testing prior to 1961 was (150/3000) five percent of the natural background radiation dose at sea-level; and the seventy year population dose was (200/7000) about three percent of the natural background radiation dose at sea-level. (10: HASP 1961.)

Nuclear weapons testing in 1961-1963 produced fission products equal to all previous testing through 1958. Because a large fraction of the 1961-1963 fission yield was produced by air bursts at the Russian northern (Arctic) proving grounds, which resulted in fission debris that has a much shorter residence time in the stratosphere, the above radiation dosages would be more than doubled (actually about 2.5 times) the previous (through 1958) lifetime radiation doses to

New York Daily News May 11, 1959

The Fateful Issue of Fallout—Rumor, Truth and Confusion

(Editor's Note: One of the most important—and most controversial issues—of our time is the problem of atomic fallout. Will it give your children cancer or will it injure the sensitive tissues of babies? Is it silently damaging the carriers of heredity so that thousands of people in future generations will be unnecessarily injured of killed? These life-and-death issues, the subject of Congressional hearings, are discussed and to some extent clarified in a series of two articles from THE NEWS' *Washington Bureau.)*

By MICHAEL O'NEILL

Washington, May 10.—The issue of atomic fallout, one of the most fateful of our time, has become such a colossal muddle that most Americans can't decide whether to be scared or blase—or, in frustration, just plain indifferent. It's gotten to the point where the confusion is almost as bad as the radiation. Scientists, politicians, diplomats and a miscellaneous assortment of ax-grinders are all sounding off in every direction.

(Associated Press foto)

Drs. Willard Libby (left) and Frank Shelton appear before subcommittee during extensive hearings on atomic fallout.

The supermarket of opinion provides both forecasts of eventual suicide for the human race and assurances that fallout is no more dangerous than a dental X-ray, or a ride in the country on a Sunday afternoon. And in the middle of it all, as usual, is the ordinary citizen who is uncertain about everything except that if anybody makes a mistake he'll probably be the loser.

In four days of hearings last week, a subcommittee of the Senate-House Atomic Energy Committee sought to bring some order out of the chaos. More than two dozen nationally known authorities—from the Atomic Energy Commission, the Public Health Service, and university laboratories—were summoned to report on the present state of our fallout knowledge.

STILL A THREAD OF AGREEMENT

As they probed the extraordinary complexities of the problem, as they argued over some questions and confessed their ignorance about many others, they tended to reinforce the public impression of confusion and controversy. But throughout their testimony there was still a tenuous thread of agreement on some fundamental issues. And even if an understanding of these does not clarify everything, it at least helps put the fallout threat in better perspective.

To begin with, the scientists on both sides of the dispute agree there is nothing good about fallout. On this there is no controversy. They believe that the silent, unseen rain of radioactivity from nuclear explosions is adding to the world's burden

FIGURE 10-23. FALLOUT--RUMOR, TRUTH AND CONFUSION

the northern hemisphere populations, or 0.5 rem (500 millirem). (Table 10-5.)

The strontium-90 produced by weapons testing through 1958 was apportioned approximately as follows: mesosphere (upper stratosphere), 0.4 megacuries; lower stratosphere, 5.5 megacuries (3.0 U.S., U.K., and 2.5 U.S.S.R.); troposphere, 0.6 megacuries; local Pacific Ocean, 2.7 megacuries (for a total of 9.2 megacuries). Of the 0.6 megacuries of tropospheric fallout, 0.5 megacuries probably fell into the sea within a few weeks, so that only 0.1 megacuries descended on land areas. Consequently, any worldwide sampling of delayed fallout, which is made on land, will reflect mainly the 5.9 megacuries of strontium-90 from stratospheric fallout. The AFSWP sampling of the lower stratosphere by U-2 aircraft indicated that the average during early calendar 1958 was about 1.1 megacuries remaining in the stratosphere from all previous testing, with an additional 1.0 megacuries being added by the 40 megatons of fission yield during 1958. The rhodium-102 tracer element incorporated into the high altitude ORANGE event during 1958 (see Chapter 9), aided materially in determining the residence time for fission debris in the stratosphere.

By the end of 1959, the measured stratospheric reservoir of strontium-90 was down to 1.2 megacuries, and the worldwide surface burden was 4.2 megacuries due to stratospheric fallout. It was found that best agreement with actual stratospheric and ground inventory determinations was obtained if it was assumed that on the average 50 percent of the strontium-90 activity from land surface bursts and 70 percent from water surface shots remained suspended in the atmosphere long enough to appear as delayed fallout. (Figure 10-24, key fallout problem solved.) (Appendix B, fallout from nuclear weapons tests.)

WORLDWIDE FALLOUT RADIATION DOSES–NUCLEAR WAR

While preparing for Congressional hearings on fallout to begin in May 1959, I was informed that I would be the lead-off witness for hearings on "Biological and Environmental Effects of Nuclear War" in June 1959. One of the calculations that would be useful for the later hearings was the worldwide fallout that would accompany a massive strategic nuclear weapons exchange between the United States and the Soviet Union. The values in Table 10-6 have been brought up to date for a 1988 strategic "Nuclear Weapons War." (12: "Soviet Military Power - 1987.")

The 180 megatons of fission products resulting from all nuclear weapons testing through 1963, gave a lifetime dose of 0.5 roentgens to the worldwide population in the northern hemisphere. From Table 10-6, it is estimated that a "Nuclear War--1988" between the United States and the Soviet Union would result in 3,800-6,000 megatons of fission yield. Assuming that the individual warhead yields, heights of burst, and northern latitudes of the nuclear war were about like the distribution in the nuclear testing data base, then the worldwide fallout dose is calculated to be 10 r to 16 r, which is to be compared with natural background radiation doses (at sea-level) of 7 r, or, about the same increment to radiation as living at an altitude of 5000 feet, instead of at sea-level.

Throughout this discussion on worldwide fallout, the reader must appreciate the distinction between "local" and "worldwide" fallout and the

TABLE 10-5. ALL NUCLEAR WEAPON TESTING (PRE-MORATORIUM) (11: ENW-1962, TABLE 9.161.)

YEARS	FISSION YIELD (KILOTONS)			TOTAL YIELD (KILOTONS)	
	AIR BURST	GROUND SURFACE	WATER SURFACE	AIR BURST	SURFACE BURST
1945-51	190	550	20	190	570
1952-54	1,000	15,000	22,000	1,000	59,000
1955-56	5,000	1,500	6,000	11,000	17,000
1957-58	31,000	4,000	4,600	57,000	28,000

(One megaton of fission yield produces about 0.1 megacuries of Sr-90.)
(All nuclear testing through 1958 produced 9.2 megacuries of Sr-90.)

THE EVENING STAR
Washington, D. C., May 11, 1959

Key Fallout Problem Is Reported Solved

By RICHARD FRYLUND
Star Staff Writer

One of the great problems of the radioactive fallout hazard has been solved.

Witnesses before the Joint Congressional Committee on Atomic Energy reported yesterday that scientists now know the mechanism of fallout—how the radioactive material gets high into the air, how it circulates, how long it stays aloft, how it comes back to earth and where it falls.

Until yesterday this information has been a matter of public dispute by scientists and sometimes bitter, partisan debate in Congress and Federal agencies.

This leaves one more vast area of uncertainty, however, before the true hazard of radioactive fallout can be assessed. That area is the biological effect of fallout—its effect on people.

Five-Point Summary

To sum up, the new picture of fallout, now generally accepted by all the scientists involved, is this:

First the radioactive debris from atomic explosions equivalent to some 30 million tons of TNT is now in the stratosphere. This is considerably less than many previous estimates. The significance is that less remains to fall on us, but less future testing can be done without increasing the level of hazard.

Second, the material does not fall uniformly on the world's just and unjust. It is concentrated in the northern hemisphere in the latitudes which include the United States. This settles an old argument over uniformity.

Third, the dangerous material falls out rather quickly. A year ago scientists thought it took seven years for half of the material to fall out, seven years for half of the remainder, and so on. After yesterday, the accepted figure is two years half-residency for material blasted upward near the equator and one year for material sent up near the Arctic. Therefore, the far-north Soviet tests are the most dangerous.

Hits Middle Latitudes

Fourth, the material does not filter down evenly all over the world through the tropopause (the dividing line, about five miles high, between the stratosphere, where the material rests in the still, almost airless sky, and the troposphere, the turbulent lower area where the weather is). It comes through that barrier only at "breaks" which exist at about 40 degrees where rainstorms carry it on down to the surface of the earth.

This new concept accounts for the concentration belt which makes radioactivity in the United States, particularly the northern regions, high.

Fifth, there are seasonal variations in fallout. The spring is heaviest. We are now headed into the worst fallout spring since the first A-bomb.

Will Study Effects

Dr. Frank Shelton, technical director of the Armed Forces Special Weapons Project, who just finished the heart of the definitive mechanism survey, believes efforts of Government scientists can now be turned most profitably to a determination of how human beings, plants and animals are affected by the fallout.

After another year's double-check in the northern and southern hemisphere of the fallout mechanism, Dr. Shelton believes his own shop could stop operations.

The radiation subcommittee of the Atomic Energy Committee is holding a series of hearings under the chairmanship of Representative Holifield, Democrat of California, to bring fallout information up to date and to determine what can be taken out of the realm of controversy and what can be presented to the public as reasonably sure scientific fact.

Yesterday's findings were the result of a global survey of fallout. Measurements were taken in balloons and airplanes, in rain clouds, in lakes, wheat fields and on rooftops. Hundreds of scientists in the Defense Department, AEC, Weather Bureau and Public Health Service were involved.

Scientists Testify

The first witness, Dr. C. L. Dunham, chief of the biology and medicine division of the Atomic Energy Commission, summed up the fallout picture in a 127-page report that emphasized the need for more research on the physical hazard of radiation. Dr. Francis J. Weber, chief of the division of Radiological health of the Public Health Service, recommended that "we continue to measure and measure and that the research now under way be expanded."

Aspects of the fallout mechanism were then discussed by Mr. Joshua Holland, division of biology and medicine, AEC; Dr. Shelton; Dr Lester Machta, United States Weather Bureau; Dr. E. A. Martell, Cambridge Research Center, United States Air Force, and Dr. W. F. Libby, Atomic Energy Commissioner.

Before the current hearings, Congress—and the public—had not known how much potentially dangerous radioactive material was in the upper atmosphere, how fast it was falling on the food we eat or where the fallout was concentrated.

Saw Data Withheld

Committee members, particularly Mr. Holifield and Senator Anderson, Democrat of New Mexico, became convinced that the AEC and Pentagon were withholding information from the public on the danger of fallout.

Yesterday's "reveal all" testimony was not particularly comforting—it indicated the fallout danger is certainly no less than supposed—but it did indicate that the Federal agencies previously were holding out on the public more out of ignorance than a desire for secrecy.

FIGURE 10-24. KEY FALLOUT PROBLEM IS REPORTED SOLVED

The Evening Star June 22, 1959

World Would Survive Atom War, Expert Says

Congress Is Told Countries Not Attacked Would Suffer, But Still Could Go On

By RICHARD FRYKLUND
Star Staff Writer

The popular conception of a world population destroyed by fallout after a nuclear war, is mistaken, a congressional committee was told today.

Dr. Frank Shelton, technical director of the Defense Department's Atomic Support Agency, told a subcommittee of the Joint Committee on Atomic Energy that world-wide fallout would not threaten the survival of countries not attacked, even during a "large-scale" nuclear war.

The best-selling novel "On the Beach" is wrong, Dr. Shelton said, in picturing a deadly fallout cloud gradually encompassing the entire earth.

"Medium" War Postulated

The committee today opened a week-long series of hearings on the effects of a hypothetical war between the United States and Russia. The group envisions medium scale war in which the United States, Russia and some European countries are hit directly by large nuclear bombs.

Dr. Shelton said the radioactive strontium 90 in the bones of people around the world would rise only "slightly higher than the maximum permissible concentrations" set as a guide to radiation hazard. The added gynetic dose would be only the equivalent of the present natural radiation, he said.

Dr. Shelton concluded that other countries would survive handily even though they might have grounds to worry about an increase in cancer and defective children in future generations.

Death to All in 7 Miles

No person within seven miles of a large nuclear explosion would have more than a slim chance to survive, Dr. Shelton said.

The committee is assuming that Washington would be hit by two bombs, one of 8 megatons and the other of 10 megatons. A megaton is the equivalent in blast destruction of a million tons of TNT.

Dr. Shelton said that direct radiation from a 10-megaton bomb would kill everyone exposed to it within 2 miles of the blast. Even brick buildings would be destroyed in an area 7 miles from the explosion, crushing people who took shelter and leaving others exposed to fallout radiation and heat damage.

Persons within 25 miles of the explosion, Dr. Shelton said, would suffer second - degree burns on all exposed parts of their bodies. The bomb would make a 240-foot-deep crater, 2,500 feet in diameter.

Dr. Shelton said people downwind from the blast would be killed by fallout radiation in an area roughly 100 miles long and 17 miles wide.

Most wooden buildings would catch fire in an area 25 miles from the explosion.

Senator Anderson, Democrat of New Mexico, asked what these blast figures would mean in simple human terms. "What will happen to me, standing 10 miles from the Capitol downwind from the center of the explosion?" he asked.

Dr. Shelton said almost all wooden houses and most brick buildings in his area would be destroyed during the first minute after the explosion. The fallout effect would not come for a half hour, he said, but it would be strong enough when it arrived to give an unsheltered person a deadly dose of radiation in minutes.

Attack Date Assumed

The hearings, according to Subcommittee Chairman Holifield, Democrat of California, are designed to clear up the "considerable confusion" in the public mind about the effects of nuclear war. The hearings will assume that 224 cities, military installations and Atomic Energy Commission centers, will be hit by 1,446 megatons of large nuclear bombs. The attack takes place at 7 a.m. Washington time, in mid-October. The weather is assured to be that which actually existed on October 17, 1958.

Eugene Quindlen of the Office of Defense Mobilization said casualties and destruction will be based on an assumption that no cities are evacuated, that no extensive air raid shelter systems exist, but that people have enough warning to hide in buildings.

Chairman Holifield read a message to the subcommittee from Lt. Gen. James E. Gavin, former head of research and development for the Army, saying that the conditions of the atomic war assumed by the committee are "entirely realistic."

FIGURE 10-28. WORLD WOULD SURVIVE ATOM WAR, EXPERT SAYS

was not criticized publicly by anybody. The only criticism which was made of that decision was that the cutback on defense against bombers did not go far enough. Yet some years ago, in 1956, when General Partridge testified on the state of our defenses, he made it very clear they were not adequate to defend our country and would not be adequate in the near future; his testimony did not depend in any sharp way on large estimates of the number of Russian long-range bombers; their TU-4's, and Badgers, and small numbers of Bears and Bisons, being sufficient. They did not have to have 500 or 1,000 Bears and Bisons to do the job."

"The reason why there is not criticism of the decision to cut back on air defense is that people believe we must deter all-out war, we must be able to fight limited wars, we must have arms control and that is all. They do not really believe we have to be able to fight a general war, usually not because they are certain one cannot happen, but because they do not believe that anyone can survive a general war. They do not believe that there is a significant difference between victory, stalemate, and defeat."

"The testimony before this Committee was, I think, in that sense very salutatory. As far as I know, Dr. Frank Shelton was the first Government official to make the flat statement that the next war would not destroy all human beings, worldwide."

"This may strike those who know, in this committee room, as a rather silly view (that the next war would end all civilization), that is held by maybe a few uneducated laymen. It is not like that. Very distinguished scientists hold that view. And I mean very distinguished. And a couple of years ago they would have been willing to argue with you numerically that they were right. . . . There was a recent debate in the New Leader magazine between Bertrand Russell and Sidney Hook on, 'Was it legitimate, or was it not, to risk killing all human beings in the world in the attempt to resist Communism?' That was a serious debate. Nobody raised the question, that the debate was about a hypothetical subject which was not at issue. One does not kill all human beings, or even a majority of them, in a war. . . ."

". . . Some of the Europeans raised the question: Would American aid be on the way if the Russians seriously challenged us? Would we (the Americans) live up to our alliance obligations? . . ."

". . . Now let me ask every man in this room to put himself in the place of the President of the United States. Assume that the Russians have done something very horrible, say dropped a bomb on London, on Rome, Paris, Berlin, the worst thing you can imagine, but have not touched the United States. By some mechanism the President cannot react immediately. He has 24 hours to think over what he will do; at which point he has to decide whether to press the button and punish the Russians, but in turn accept the retaliatory attack upon the United States. . . . I do not know how the President would act . . . We cannot say whether the Soviet retaliatory threat would be effective at exactly 5 or 30 or 100 million dead (Americans). . . . many Europeans will say, 'At no price will the Americans retaliate . . . .' On the other hand, the typical American will say, 'We cannot be bluffed or blackmailed at any price.'"

"It is important, in other words, to differentiate very sharply between what I have called Type One Deterrence, which is trying to deter a direct attack on the United States, and what I have called Type Two Deterrence, which is trying to deter an extremely provocative action. . . ."

"As long as we think of a thermonuclear war as a sort of end of history, we may not feel acutely uncomfortable about placing all of our reliance either on deterrence or on measures to alleviate tension, as this seems to be all we can do. . . . (However, we should actually feel very uncomfortable, because that isn't the way the world really is)."

Whereupon, at 12:30 p.m., the hearing was recessed . . . .

THE LAST YEAR WAS THE WORST YEAR

For the Eisenhower Administration, 1960 was a bad year, and also the last year of a full two-term Presidency. As bad years go, it was comparable to the Reagan Administration's year of "selling arms to Iran for hostages." Both Presidents got caught, publicly, doing what they thought was in the best interests of the United States, but the lower level management of the operations "screwed up." In Eisenhower's case,

FIGURE 11-5. TRUCKEE EVENT AT CHRISTMAS ISLAND

Weather Forecast
Honolulu and vicinity: Partly cloudy today, tonight and Tuesday, with a few scattered light showers, mainly night and early morning. Trades 14-24 miles per hour. High for yesterday at Honolulu Airport, 84; low, 70. Trace of rain.

Honolulu Star-Bulletin

Vol. 51, No. 189 HONOLULU, HAWAII, MONDAY, JULY 9, 1962 ★★★★ HOME EDITION 10¢

N-Blast Produces Colorful Display

Color photos by Terry Luke show how last night's hydrogen bomb explosion looked from Punchbowl. The first photo was exposed at exactly 11 p.m., the moment of ignition. The light was so intense that the sky appears blue as in daylight. The light spot in the sky above the elevator shaft of the new First National Bank Building is the bomb center. Center photo was taken about 11:01 p.m. with the sky dominated by greenish colors. The right hand photo was made at about 11:05 p.m. just before the color faded.

Spectacular Test Shot Lights All Islands

A hydrogen bomb at least 50 times as powerful as the uranium atom bomb dropped on Hiroshima lighted the entire Central Pacific Ocean for an instant last night, then set sunset colors running through the sky for six more minutes.

It caused worried phone calls to newspapers as far as 3,900 statute miles from Johnston in Auckland, New Zealand.

Sightings were also reported from Samoa, Fiji and planes between Hawaii and the West Coast.

Fired possibly 300 miles above Johnston Island it was a spectator show for thousands of persons in Hawaii but today scientists are beginning the task of collecting and analyzing data from around the world to determine its effects.

After a series of failures and postponements, it was a satisfying first success for U.S. Joint Task Force 8 in its planned high level test series.

An Atomic Energy Commission official at Pearl Harbor this morning described the explosion as "basically a scientific experiment."

He said he doubted whether scientists findings would be made known until "sometime in the future."

"They will be studying this for weeks and months to come," the spokesman said.

The spokesman added that the height of the detonation would continue to be kept secret. So would the yield of the nuclear device.

There has been no confirmation that a second test will be conducted from Johnston Island. Three and possibly four were scheduled.

Precisely at H-Hour as a short-waved countdown reached zero, the bomb flashed with instantaneous daytime brilliance in Honolulu's southwest sky.

It was perhaps 15 degrees above the horizon, indicating an altitude of several hundred miles. The bomb center registered a pinpoint of light on camera films.

The first flash was followed by the appearance of

Turn to Page 1-A, Column 1

★ ★ ★

Shock Wave May Have Put Out Lights

The City-County Street Lighting Department said today shock waves from the Johnston Island nuclear blast blew out fuses in several areas of the Island last night.

Raymond Stephenson, dispatcher for the department

More Stories on Pages 2-A, 2-B, 24-B

attributed the damage to shock waves.

"The bomb caused blown fuses in Kaimuki, Kahala, Kalihi, Maili, Waianae, Makaha, Wahiawa, Kailua and Sandy Beach," he said.

Police also reported the civil defense siren at Waianae was triggered immediately after the nuclear blast. Whether the accidental sounding was coincidental or directly connected with

Turn to Page 1-A, Column 4

Bulletin

WASHINGTON, July 9 (AP) — The Federal Reserve Board today reduced its margin requirements — the down payments which must be made on stock purchases —from 70 per cent to 50 per cent effective tomorrow.

The Johnston nuclear blast flooded the beach at the Hawaiian Village in Waikiki with an eerie light last night.—Star-Bulletin Photo by Amos Chun.

★ ★ ★

Blackouts Brief In Communications

The thermonuclear blast over Johnston Island last night didn't affect communications as much as expected but the Federal Aviation Agency said it experienced occasional blackouts for about two hours after the 11 p.m. blast.

But since then communication has been normal, an F.A.A. spokesman said.

Australia and Japan also reported similar brief interruptions soon after the blast.

The F.A.A. official in Honolulu said the "occasional short outages (signal going out) affected point-to-point communication in all directions."

He estimated the duration at 20 to 30 minutes, but the interruptions disappeared after about two hours and communication has been normal since.

He said communication between Honolulu Airport and aircraft in the air was perfect at all times.

Some Honolulu radio stations were washed out by interference but returned to the air immediately.

The Japanese Overseas Telephone and Telegraph Company reported trans-pacific telephone connections with Honolulu, Oakland, and Buenos Aires, Argentina, were knocked out right after the explosion but service was restored a short time later, Associated Press said.

In Sydney, Australia, an

Turn to Page 2-B, Column 8

Most Going Into Orbit

Little Fallout Seen From Test

WASHINGTON, July 9 (UPI)—Atomic experts expect little if any radioactive fallout from the nuclear explosions in space over Johnston Island.

Some of the bomb debris, perhaps as much as half, may be hurled free of the earth's gravitational field and wind up wandering through space in long orbits around the sun. A part of what is left is expected to go into orbit around the earth.

The remainder may well be held aloft, far above the weather regions of the atmosphere, so long and be dispersed so widely that it will be comparatively harmless by the time it comes down.

"There is no doubt," one authority told United Press International, "that space tests are the safest of all above-ground shots from the standpoint of fallout."

A Defense Department study issued a little over a year ago estimated that half of the radioactive debris from a megaton bomb exploded at an altitude of 100

Turn to Page 1-A, Column 6

DIRECTORY

FIGURE 11-21. STARFISH EVENT -- HONOLULU NEWSPAPER

FIGURE 11-28. STARFISH EVENT FROM CHRISTMAS ISLAND

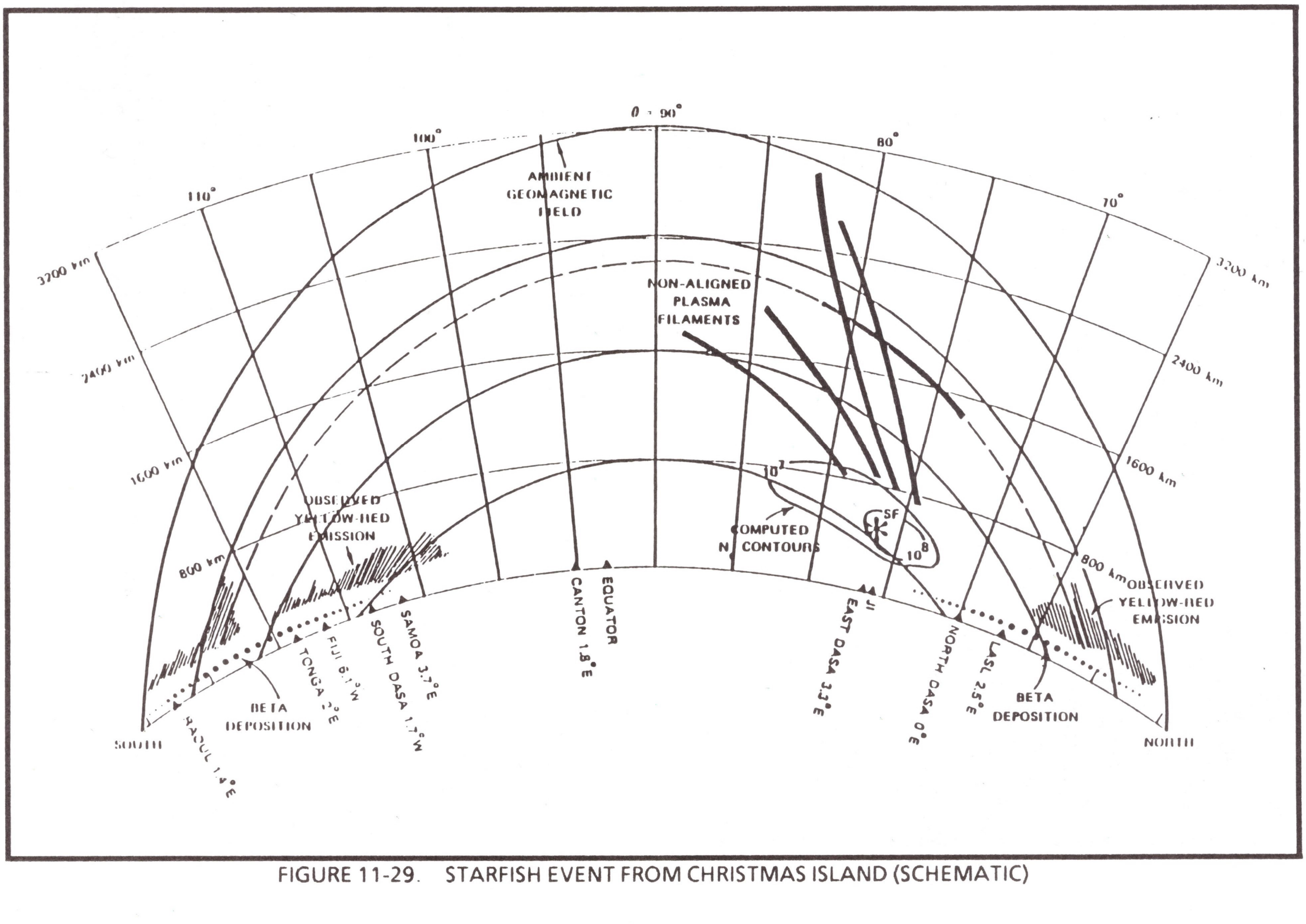


FIGURE 11-29. STARFISH EVENT FROM CHRISTMAS ISLAND (SCHEMATIC)

Where To Find It

The Honolulu Advertiser

NEWS IN DEPTH
FULL HOUR
KGU 6:00 p.m.

★ ★ ★ 107th YEAR NO. 53,891 FRIDAY, NOVEMBER 2, 1962 10 CENTS

Soviet Suggests Red Cross

Castro Refuses UN Inspections

See Story This Page, Column 1

2:09 A.M. *60 Seconds Later* *75 Seconds Later* *120 Seconds Later* *180 Seconds Later*

FIGURE 11-39. KINGFISH EVENT IN HONOLULU NEWSPAPER

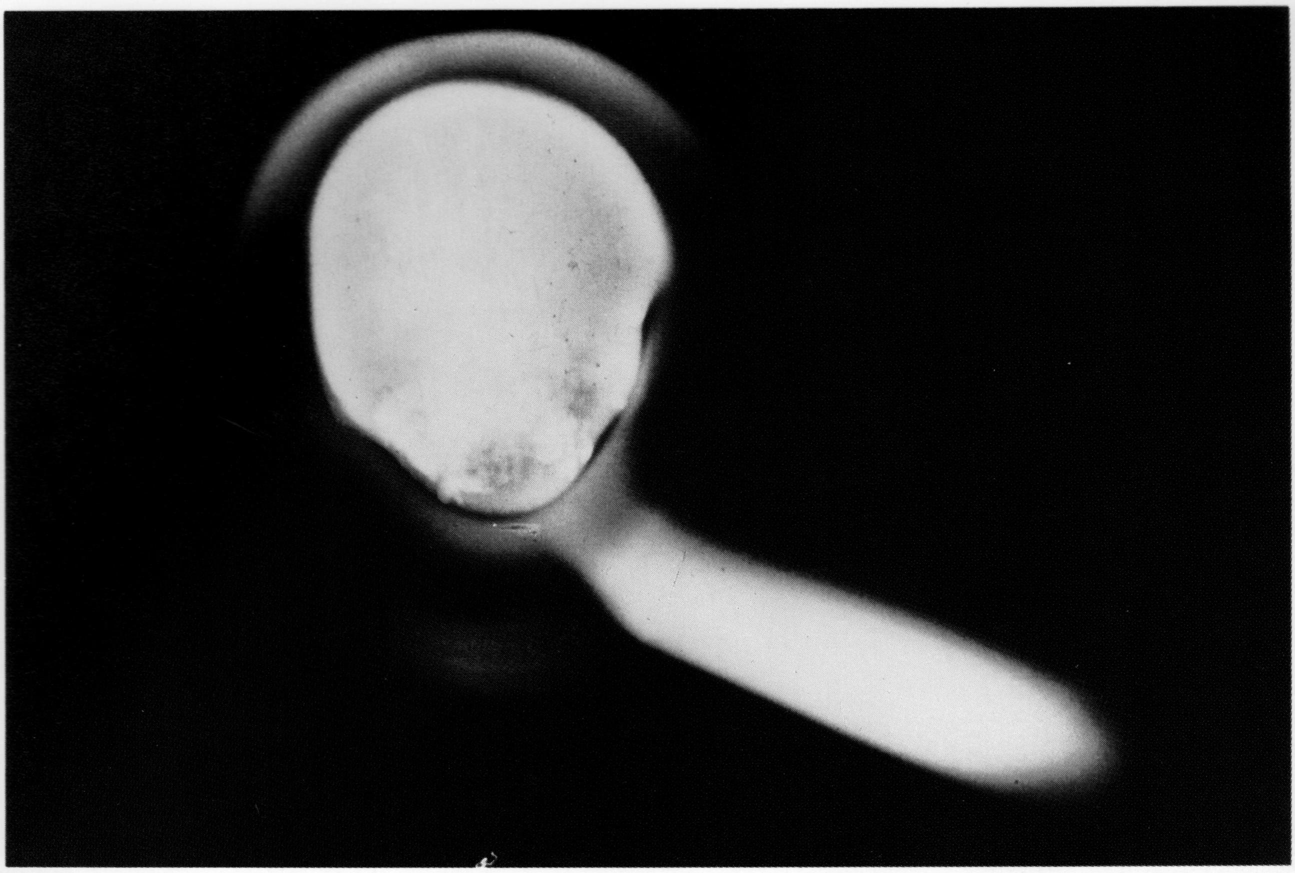


FIGURE 11-40. KINGFISH EVENT FROM AIRCRAFT

test ban treaty with the Russians. (Figure 11-41, Nike-Hercules Missile; Figure 11-42, TIGHTROPE.)

Statement by the President on the Conclusion of Atmospheric Nuclear Tests in the Pacific: (6: item 503, pp. 821)

". . .The medium altitude shot fired this morning off Johnston Island concludes our present atmospheric test series in the Pacific. Underground nuclear weapons tests, free from fallout, are continuing in Nevada."

". . .I hope that in the next months we can conclude an effective test ban treaty, so that the world can be free from all testing. Agreement in this area would be an important first step toward our continuing goal of workable disarmament arrangements which can cut down the threat of war. . . ."

Prior to Senate ratification of the Limited Nuclear Test Ban Treaty in 1963, hearings were held by a Senate Armed Services subcommittee on the military implications of the proposed treaty. I assisted in preparation of portions of the testimony given by Major General Robert H. Booth, Chief-Defense Atomic Support Agency of the Department of Defense, presented on 28 May and 5 June 1963. Portions of General Booth's testimony appear verbatim in the Senate Subcommittee's summary report of the hearings, which conveys our assessment of Operation DOMINIC - FISHBOWL:

"Important as are programs associated with the acquisition of new or improved types of weapons, the advent of the missile age and the adoption of a second-strike or retaliatory strategic policy by the United States has elevated to a first priority tests to determine the effects of nuclear explosions on hardened missile sites and control centers, on reentry bodies in flight, and on radar, electronic, and communication systems. Of equal importance have become tests to determine what unique effects are produced by nuclear explosions in space, the atmosphere, and under water so that the knowledge gained might be exploited for defensive purposes or our own weapons systems designed to resist them."

". . .To date, only Polaris has been subjected to a full-scale test, including the explosion of the nuclear warhead. . . ."

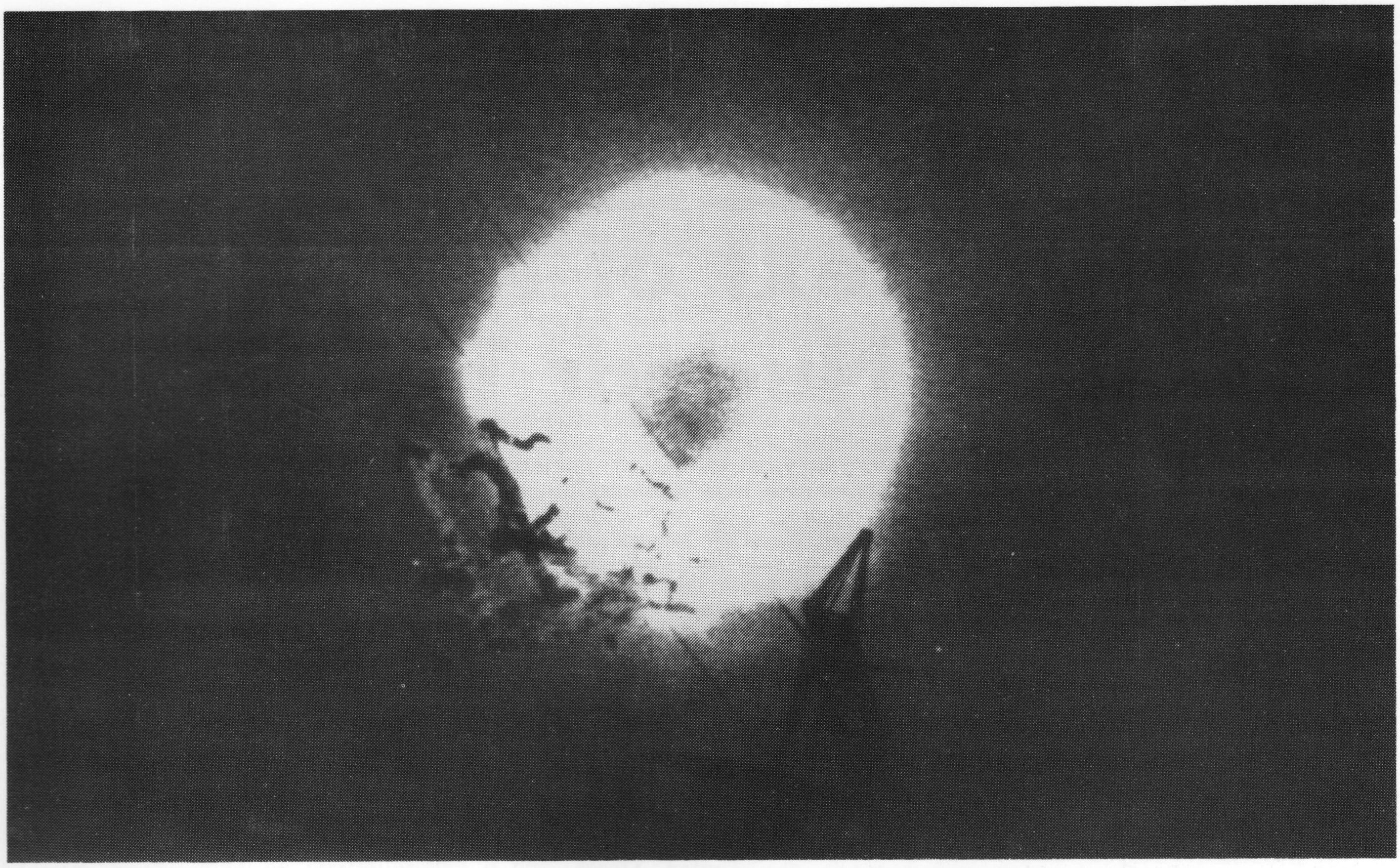


FIGURE 11-42. TIGHTROPE EVENT FROM JOHNSTON ISLAND

"In the field of weapons effects experiments related to the design and development of an effective antiballistic missile (ABM) system the evidence, although less conclusive, indicates that the Soviet Union in 1961 and 1962 conducted a series of complex high altitude operations which, if properly instrumented, could provide substantial and important data on various types of radar blackout and nuclear effects. These Soviet experiments were clearly dictated by an ABM development program."

"The United States has conducted no experiments comparable in complexity to these Soviet operations and a disturbing number of the U.S. high-altitude-effects experiments which were conducted were compromised either by considerations unrelated to the technical objectives of the test program, by inadequate or faulty instrumentation, or by operational inadequacies. Based on the testimony we have received, there can be little doubt but that the quantity and quality of information available to the United States on high altitude nuclear effects is inadequate for the Nation's military needs."

Joint Task Force Eight always gave first priority to AEC nuclear weapons development requirements for the two nuclear weapons laboratories, Los Alamos and Lawrence Radiation Laboratory, but lacked the necessary expertise to conduct complex missile operations in support of DOD high altitude nuclear weapons effects tests. The United States missed its opportunity on Operation DOMINIC-FISHBOWL. The finality of the lost opportunity was clinched with the 1963 Limited Test Ban Treaty prohibiting all atmospheric nuclear testing, which has continued enforce for twenty-five years, and will continue indefinitely.

APPENDIX A

KENNEDY'S NUCLEAR TEST REPORT

2 March, 1962

Here Is Text of President Kennedy's Nuclear Test Report

WASHINGTON— (AP) —Following is the text of President Kennedy's nationally-broadcast address Friday night on nuclear testing and disarmament:

Good evening:

Seventeen years ago man unleashed the power of the atom. He thereby took into his mortal hands the power of self-extinction. Throughout the years that have followed, under three successive presidents the United States has sought to banish this weapon from the arsenals of individual nations. For us all the awesome responsibilities entrusted to this office, none is more somber to contemplate than the special statutory authority to employ nuclear arms in the defense of our people and freedom.

But until mankind has banished both war and its instruments of destruction, the United States must maintain an effective quantity and quality of nuclear weapons, so deployed and protected as to be capable of surviving any surprise attack and devastating the attacker. Only through such strength can we be certain of deterring a nuclear strike, or an overwhelming ground attack, upon our forces and allies.

Only through such strength can we in the free world—should that deterrent fail—face the tragedy of another war with any hope of survival. And that deterrent strength, if it is to be effective and credible when compared with that of any other nation, must embody the most modern, the most reliable and the most versatile nuclear weapons our research and development can produce.

The testing of new weapons and the effects is necessarily a part of that research and development process. Without tests —to experiment and verify— progress is limited. A nation which is refraining from tests obviously cannot match the gains of a nation conducting tests. And when all nuclear powers refrain from testing, the nuclear arms race is held in check.

That is why this nation has long urged an effective worldwide end to nuclear tests. And that is why in 1958 we voluntarily subscribed, as did the Soviet Union, to a nuclear test moratorium, during which neither side would conduct new nuclear tests, and both East and West would seek concrete plans for their control.

Moratorium Broken

But on Sept. 1 of last year, while the United States and the United Kingdom were negotiating in good faith at Geneva, the Soviet Union callously broke its moratorium with a two-month series of more than 40 nuclear tests. Preparations for these tests had been secretly underway for many months. Accompanied by new threats and new tactics of terror, these tests — conducted mostly in the atmosphere — represented a major Soviet effort to put nuclear weapons back into the arms race.

Once it was apparent that new appeals and proposals were to no avail, I authorized on Sept. 5 a resumption of U.S. nuclear tests underground, and I announced on Nov. 2—before the close of the Soviet series—that preparations were being ordered for a resumption of atmospheric tests, and that we would make whatever tests our security required in the light of Soviet gains.

This week, the National Security Council has completed its review of this subject. The scope of the Soviet tests has been carefully reviewed by the most competent scientists in the country. The scope and justification of proposed American tests have been carefully reviewed, determining which experiments can be safely deferred, which can be deleted, which can be combined or conducted underground, and which are essential to our military and scientific progress. Careful attention has been given to the limiting of radioactive fallout, to the future course of arms control diplomacy, and to our obligations to other nations.

Every alternative was examined. Every avenue of obtaining Soviet agreement was explored. We were determined not to rush into imitating their tests. And we were equally determined to do only what our own security required us to do. Although the complex preparations have continued at full speed while these facts were being uncovered, no single decision of this administration has been more thoroughly or more thoughtfully weighed.

Having carefully considered these findings — having received the unanimous recommendations of the pertinent department and agency heads—and having observed the Soviet Union's refusal to accept any agreement which would inhibit its freedom to test extensively after preparing secretly—I have today authorized the Atomic Energy Commission and the Department of Defense to conduct a series of nuclear tests—beginning when our preparations are completed, in the latter part of April and to be concluded as quickly as possible (within two or three months)—such series, involving only those tests which cannot be held underground, to take place in the atmosphere over the Pacific Ocean.

Restricted Fallout

These tests are to be conducted under conditions which restrict the radioactive fallout to an absolute minimum, far less than the contamination created by last fall's Soviet series. By paying careful attention to location, wind and weather conditions, and by holding these tests over the open sea, we intend to rule out any problem of fallout in the immediate area of testing. Moreover, we will hold the increase in radiation in the northern hemisphere, where nearly all such fallout will

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occur, to a very low level.

Natural radioactivity, as everyone knows, has always been part of the air around us, with certain long-range biological effects. By conservative estimate, the total effects from this test series will be roughly equal to only 1 pct. of those due to this natural background. It has been estimated, in fact, that the exposure due to radioactivity from these tests will be less than 1-50 of the difference which can be experienced, due to variations in natural radioactivity, simply by living in different locations in this country. This will obviously be well within the guides for general population health and safety, as set by the Federal Radiation Council; and considerably less than 1-10 of 1 pct. of the exposure guides set for adults who work with industrial radioactivity.

Nevertheless, I find it deeply regrettable that any radioactive material must be added to the atmosphere—that even one additional individual's health may be risked in the foreseeable future. And however remote and infinitesimal those hazards are judged to be, I still exceedingly regret the necessity of balancing these hazards against the hazards to hundreds of millions of lives which would be created by any relative decline in our nuclear strength.

In the absence of a major shift in Soviet policies, no American president—responsible for the freedom and safety of so many people—could in good faith make any other decision. But because our nuclear posture affects the security of all Americans and all free men—because this issue has aroused such widespread concern—I want to share with you and all the world, to the fullest extent our security permits, all of the facts and thoughts which have gone into my decision.

Many of these facts are hard to explain in simple terms—many are hard to face in a peaceful world—but these are facts which must be faced and must be understood.

Had the Soviet tests of last fall reflected merely a new effort in intimidation and bluff, our security would not have been affected. But in fact they also reflected a highly sophisticated technology, the trial of novel designs and techniques, and some substantial gains in weaponry. Many of their tests were aimed at improving their defenses against missiles—others were proof tests, trying out existing weapons systems—but over one-half emphasized the development of new weapons, particularly those of greater explosive power.

Cites Giant Blast

A primary purpose of these tests was the development of warheads which weigh very little compared to the destructive efficiency of their thermonuclear yield. One Soviet test weapon exploded with the force of 58 megatons—the equivalent of 58 million tons of TNT. This was a reduced-yield version of their much-publicized hundred-megaton bomb. Today, Soviet missiles do not appear able to carry so heavy a warhead. But there is no avoiding the fact that other Soviet tests, in the 1-5 megaton range and up, were aimed at unleashing increased destructive power in warheads actually capable of delivery by existing missiles.

Much has also been said about Soviet claims for an anti-missile missile. Some of the Soviet tests which measured the effects of high altitude nuclear explosion—in one case over 100 miles high—were related to this problem. While apparently seeking information (on the effects of nuclear blasts on radar and communication) which is important in developing an anti-missile defense system, these tests did not, in our judgment reflect a developed system.

In short, last fall's tests, in and by themselves, did not give the Soviet Union superiority in nuclear power. They did, however, provide the Soviet laboratories with a mass of data and experience on which, over the next two or three years, they can base significant analyses, experiments and extrapolations, preparing for the next test series which would confirm and advance their findings.

And I must report to you in all candor that further Soviet series, in the absence of further Western progress, could well provide the Soviet Union with a nuclear attack and defense capability so powerful as to encourage aggressive designs. Were we to stand still while the Soviets surpassed us—or even appeared to surpass us—the free world's ability to deter, to survive and to respond to an all-out attack would be seriously weakened.

The fact of the matter is that we cannot make similar strides without testing in the atmosphere as well as underground. For, in many areas of nuclear weapons research, we have reached the point where our progress is stifled without experiments in every environment. The information from our last series of atmospheric tests in 1958 has all been analyzed and re-analyzed. It can tell us no more without new data. And it is in these very areas of research—missile penetration and missile defense, for example—that further major Soviet tests, in the absence of further Western tests, might endanger our deterrent.

In addition to proof tests of existing systems, two different types of tests have therefore been decided upon. The first and most important are called "effects tests"—determining what effect an enemy's nuclear explosions would have upon our ability to survive and respond. We are spending great sums of money on radar to alert our defense and to develop possible anti-missile systems — on the communications which enable our command and control centers to direct a response — on hardening our missiles sites, shielding our missiles and their warheads from defensive action, and providing them with electronic guidance systems to find their targets. But we cannot be certain how much of this preparation will turn out to be useless; blacked out, paralyzed or destroyed by the complex effects of a nuclear explosion.

Reason for Tests

We know enough from earlier tests to be concerned about such phenomena. We know that the Soviets conducted such tests last fall. But until we measure the effects of actual explosions in the atmosphere under realistic conditions, we will not know precisely how to prepare our future defenses, how best to equip our missiles for penetration of an anti-missile system, and whether it is possible to achieve such a system for ourselves.

Secondly, we must test in the atmosphere to permit the development of those more advanced concepts and more effective, efficient weapons which, in light of Soviet tests, are deemed essential to our security. Nuclear weapon technology is still a constantly changing field. If our weapons are to be

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more secure, more flexible in their use and more selective in their impact—if we are to be alert to new breakthroughs, to experiment with new designs—if we are to maintain our scientific momentum and leadership — then our weapons progress must not be limited to theory or to the confines of laboratories and caves.

This series is designed to lead to many important, if not always dramatic, results. Improving the nuclear yield per pound of weight in our weapons will make them easier to move, protect and fire—more likely to survive a surprise attack—and more adequate for effective retaliation. It will also, even more importantly, enable us to add to our missiles certain penetration aids and decoys, and to make those missiles effective at higher altitude detonations, in order to render ineffective any anti-missile or interceptor system an enemy might some day develop.

Whenever possible, these development tests will be held underground. But the larger explosions can only be tested in the atmosphere. And while our technology in smaller weapons is unmatched, we know now that the Soviets have made major gains in developing larger weapons of low-weight and high explosive content—of 1 to 5 megatons and upward. Fourteen of their tests last fall were in this category, for a total of 30 such tests over the years. The United States, on the other hand, had conducted, prior to the moratorium, a total of only 20 tests within this megaton range.

While we will be conducting far fewer tests than the Soviets, with far less fallout, there will still be those in other countries who will urge us to refrain from testing at all. Perhaps they forget that this country long refrained from testing, and sought to ban all tests, while the Soviets were secretly preparing new explosions. Perhaps they forget the Soviet threats of last autumn and their arbitrary rejection of all appeals and proposals, from both the U.S. and the U.N. But those free peoples who value their freedom and security, and look to our relative strength to shield them from danger — those who know of our good faith in seeking an end to testing and an end to the arms race—will, I am confident, want the United States to do whatever it must do to deter the threat of aggression.

If they felt we could be swayed by threats or intimidation—if they thought we could permit a repetition of last summer's deception — then surely they would lose faith in our will and our wisdom as well as our weaponry. I have no doubt that most of our friends around the world have shared my own hope that we would never find it necessary to test again—and my own belief that, in the long run, the only real security in this age of nuclear peril rests not in armament but in disarmament. But I am equally certain that they would insist on our testing once that is seemed necessary to protect free world security. They know we are not deciding to test for political or psychological reasons—and they also know that we cannot avoid such tests for political or psychological reasons.

Reds to Watch

The leaders of the Soviet Union are also watching this decision. Should we fail to follow the dictates of our own security, they will chalk it up, not to goodwill, but to a failure of will—not to our confidence in Western superiority, but to our fear of world opinion, the very world opinion for which they showed such contempt. They could well be enrouraged by such signs of weakness to seek another period of no testing without controls—another opportunity for stifling our progress while secretly preparing, on the basis of last fall's experiments, for the new test series which might alter the balance of power. With such a one-sided advantage, why would they change their strategy, or refrain from testing, merely because we refrained? Why would they want to halt their drive to surpass us in nuclear technology? And why would they ever consider accepting a true test ban or mutual disarmament?

Our reasons for testing and our peaceful intentions are clear —so clear that even the Soviets could not objectively regard our resumption of tests, following their resumption of tests, as provocative or preparatory for war. On the contrary, it is my hope that the prospects for peace may actually be strengthened by this decision—once the Soviet leaders realize that the West will no longer stand still, negotiating in good faith, while they reject inspection and are free to prepare further tests. As new disarmament talks approach, the basic lesson of some three years and 353 negotiating sessions at Geneva is this—that the Soviets will not agree to an effective ban on nuclear tests as long as a new series of offers and prolonged negotiations, or a new uninspected moratorium, or a new agreement without controls, would enable them once again to prevent the West from testing while they prepare in secret.

But inasmuch as this choice is now no longer open to them, let us hope that they will take a different attitude on banning nuclear tests—that they will prefer to see the nuclear arms race checked instead of intensified, with all the dangers that intensification is likely to bring: The spread of nuclear weapons to other nations; the constant increase in world tensions; the steady decrease in all prospects for disarmament; and, with it, a steady decrease in the security of us all.

If the Soviets should change their position, we will have an opportunity to learn it immediately. On the 14th of March, in Geneva, Switzerland, a new 18-power conference on disarmament will begin. A statement of agreed principles has been worked out with the Soviets and endorsed by the U.N. In the long run, it is the constructive possibilities of that conference—and not the testing of new destructive weapons—on which rest the hopes of all mankind. However dim those hopes may sometimes seem, they can never be abandoned. And however far-off most steps toward disarmament appear, there are some that can be taken at once.

The United States will offer at the Geneva conference—not in the advance expectation they will be rejected, and not merely for purposes of propaganda—a series of concrete plans for a major "breakthrough to peace." We hope and believe that they will appeal to all nations opposed to war. They will include specific proposals for fair and enforceable agreements: To halt the production of fissionable materials and nuclear weapons and their transfer to other nations—to convert them from weapon stockpiles to peaceable uses—to destroy the warheads and the delivery systems that threaten man's existence—to check the dangers of surprise and accidental attack—to reserve outer space for peaceful use—and progressively to reduce all armed

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forces in such a way as ultimately to remove forever all threats and thoughts of war.

To Renew Offers

And of greatest importance to our discussion tonight, we shall, in association with the United Kingdom, present once again our proposals for a separate comprehensive treaty—with appropriate arrangements for detection and verification—to halt permanently the testing of all nuclear weapons, in every environment: In the air, in outer space, underground or underwater. New modifications will also be offered in the light of new experience.

The essential arguments and facts relating to such a treaty are well-known to the Soviet Union. There is no need for further repetition, propaganda or delay. The fact that both sides have decided to resume testing only emphasizes the need for new agreement, not new argument. And before charging that this decision shatters all hopes for agreement, the Soviets should recall that we were willing to work out with them, for joint submission to the U.N., an agreed statement of disarmament principles at the very time their autumn tests were being conducted. And Mr. Khrushchev knows, as he said in 1960, that any nation which broke the moratorium could expect other nations to be "forced to take the same road."

Our negotiators will be ready to talk about this treaty even before the conference begins on March 14—and they will be ready to sign well before the date on which our tests are ready to begin. That date is still nearly two months away. If the Soviet Union should now be willing to accept such a treaty, sign it before the latter part of April, and apply it immediately—if all testing can thus be actually halted—then the nuclear arms race would be slowed down at last—the security of the United States and its ability to meet its commitments would be safeguarded—and there would be no need for our tests to begin.

But this must be a fully effective treaty. We know enough now about broken negotiations, secret preparations and the advantages gained from a long test series never to offer again an uninspected moratorium. Some may urge us to try it again, keeping our preparations to test in a constant state of readiness. But in actual practice, particularly in a society of free choice, we cannot keep top-flight scientists concentrating on the preparation of an experiment which may or may not take place on an uncertain date in the future. Nor can large technical laboratories be kept fully alert on a stand by basis waiting for some other nation to break an agreement. This is not merely difficult or inconvenient—we have explored this alternative thoroughly, and found it impossible of execution.

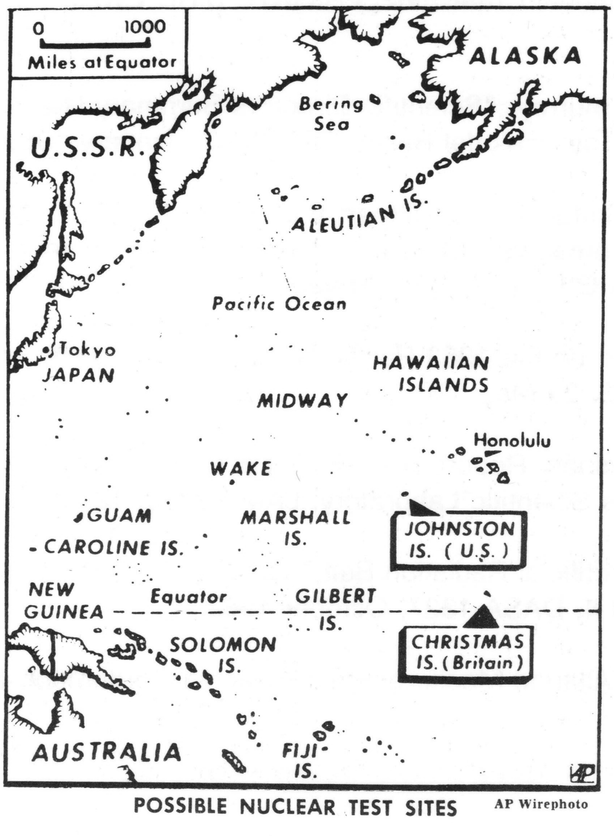
In short, in the absence of a firm agreement that would halt nuclear tests by the latter part of April, we shall go ahead with our talks—striving for some new avenue of agreement—but we shall also go ahead with our tests. If, on the other hand, the Soviet Union should accept such a treaty in the opening month of talks, that single step would be a monumental step toward peace—and both Prime Minister Macmillan and I would think it fitting to meet Chairman Khrushchev at Geneva to sign the final pact.

For our ultimate objective is not to test for the sake of testing. Our real objective is to make our own tests unnecessary, to prevent others from testing, to prevent the nuclear arms race from mushrooming out of control, to take the first steps toward general and complete disarmament. And that is why, in the last analysis, it is the leaders of the Soviet Union who must bear the heavy responsibility of choosing, in the weeks that lie ahead, whether we proceed with these steps—or proceed with new tests.

If they are convinced that their interests can no longer be served by the present course of events, it is my fervent hope that they will agree to an effective treaty. But if they persist in rejecting all means of true inspection, then we shall be left no choice but to keep our own defensives arsenal adequate for the security of all free men.

It is our hope and prayer that these grim, unwelcome tests will never have to be made—that these deadly weapons will never have to be fired—and that our preparations for war will bring us the preservation of peace. Our foremost aim is the control of force, not the pursuit of force, in a world made safe for mankind. But whatever the future brings, I am sworn to uphold and defend the freedom of the American people—and I intend to do whatever must be done to fulfill that solemn obligation.

Thank you—and good night.



POSSIBLE NUCLEAR TEST SITES AP Wirephoto